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RECENT EXPERIMENTS WITH "MINOR" ELEMENTS IN WESTERN AUSTRALIA.

(A series of four short papers continued from March issue.)

III.—RESPONSE OF WHEAT TO COPPER ON LIGHT LANDS AT WAGIN.

By A. M. Stewart,
Institute of Agriculture, University of W.A.,
and
L. J. H. Teakle,
Department of Agriculture, W.A.

(1) *Introduction.*

Striking response of wheat to copper sulphate, applied at the rate of 20 lbs. per acre, was obtained over portion of an area of 12 acres under experiment with various minor elements on Mr. A. M. Stewart's farm, Lake View, Wagin, and some response was evident over the whole of the copper treated plots.

Many years of agricultural experience persuaded one of us (A.M.S.) that the Great Southern soils of lower fertility are lacking in some factor or factors that are present in the red brown soils associated with the basic dykes which intersect the ancient granitic and metamorphic rocks which underlie most of the agricultural areas of the State. Stock grazing solely on the poorer classes of country do not make the growth or carry the bloom of animals grazing on the red brown loams which are the basis of much of the agricultural development of the Great Southern. Furthermore, when all the hay and oat requirements for the year for the working horses are obtained wholly from light land they do not seem to hold their condition. Moreover, crop returns on the more sandy and gravelly types, particularly after the first one or two crops, are frequently most disappointing, in spite of liberal dressings of superphosphate and infrequent cropping. Whiteheads are common and the plants have a tendency to cease growing when they reach the flowering stage. No satisfactory explanation of the cause had been determined.

(2) *Soils.*

The soils of the Great Southern Region (the Avon and Dwarda regions of Teakle (1938)) fall into three main groups: the first, second and third class lands of the Lands Department surveys, which were identified by the nature of their vegetation and observed fertility.

The first class land, which probably does not exceed 10 to 15 per cent. of the region, is a red brown loam usually associated with basic dykes and in the virgin state carries predominantly York gum (*Eucalyptus foecunda* var. *loxophleba*).

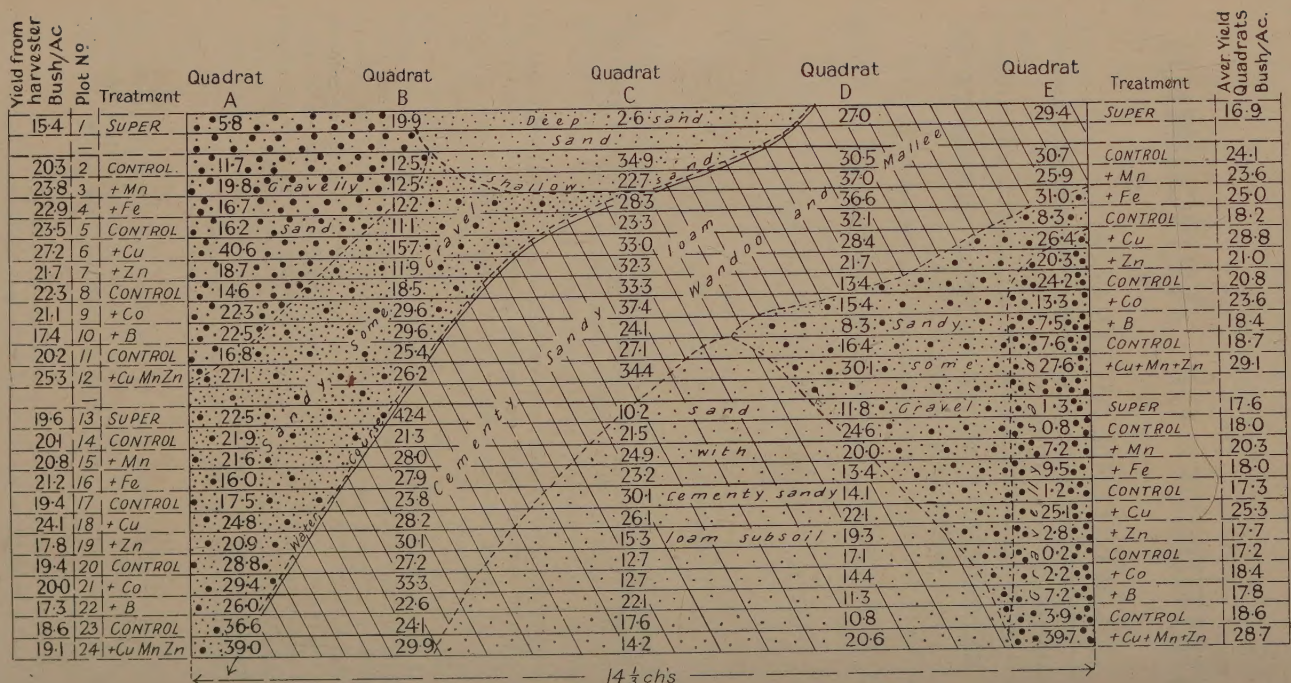

Fig.6. **SKETCH MAP OF PLOTS ON MR. A.M. STEWART'S FARM**

AT LAKE VIEW, WAGIN, 1938.

Showing soil types, Plot layouts, treatments & yield from harvester & quadrats in bushels per acre

Fig. 7.

Sheaves from square yard quadrats taken on row E (Fig. 6) at the east end of the plots where the greatest responses to copper were obtained on Mr. A. M. Stewart's farm, Lake View, Wagin. (Harvested December 6th and 7th, 1938.)

Photo.: Government Printer.

The second class land, which constitutes about half of the remainder, is a grey sandy soil overlying a hard, siliceous, cementy subsoil at a depth ranging from a few inches to three feet. Below this is generally a yellowish clay, with some red mottling, which merges into decomposing acidic rocks. The characteristic timber is wandoo (*Eucalyptus redunca* var. *elata*) with which is associated jam and sheoak (*Casuarina Fraseriana*) according to the nature and depth of the surface soil.

The third class land, constituting the remainder of the area, includes laterite-capped hills, which carry wandoo, mallet (*Eucalyptus astringens*) and scrub, and extensive sandy and gravelly heath soils, or sandplains. Third class soils are usually associated with the higher land, with detritus from the lateritic hills and ridges and with residues of the laterite capping redistributed in the course of erosion.

(3) *Experimental.*

To make qualitative observations on the effects of some minor elements on some representative types of light land, an exploratory experiment with wheat* was laid down in May, 1938, using duplicated plots of 0·43 acres running across a shallow valley between two lateritic ridges. Soils ranging from poor lateritic gravelly sands (third class land) to cementy sandy loams (second class land) were crossed by the plots (see Fig. 6) and the responses to copper, manganese, zinc and iron as commercial sulphates, to cobalt chloride and to borax were observed.

The area had been cleared and farmed for at least 25 years but had not been cropped more frequently than one year in four for many years. In the virgin state the timber ranged from typical sandplain heath with blackboys (*Xanthorrhoea* sp.) on the more gravelly types at either end of the experimental area, and near the laterite ridges, to wandoo and mallee on the better cementy sandy loam soils in the lower part of the valley. A classification of the soil types is given in Fig. 6.

Nabawa wheat was sown on clean fallow in good condition on May 20th and 21st, 1938. All plots except those receiving superphosphate only, received a basal fertiliser dressing at the rate of 1 cwt. of superphosphate and ½ cwt. of sulphate of potash per acre. The minor elements were mixed with the basal fertiliser and applied by means of a combine drill with the seed in the usual way. The drill was frequently checked for rates of sowing. The layout of the plots and the treatments in relation to soil type are shown in Fig. 6.

The rainfall at Wagin during the year 1938 in comparison with the average is shown below (in points) :—

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1938 ...	9	...	171	76	125	108	281	221	163	68	37	17	1,276
Average 1891–1937	31	55	96	129	224	306	301	244	186	128	46	38	1,784

One month after sowing, the copper treated strips were showing up a much brighter and healthier green than the other plots but there was no other detectable difference. Borax (10 lbs. per acre) and zinc sulphate (10 lbs. per acre) had a deleterious effect.

Similar observations were made one month later.

Three months after seeding, the copper treated plots were even more outstanding. Not only was the foliage attractively green, but the plants were more erect and appeared to have less dead and brown-marked leaves at the base than those

* The fertilisers were provided through the courtesy of Cuming Smith, Mt. Lyell Farmers' Fertilisers, Ltd.

under the other treatments. Plants were dug up from all plots for spectrographic analysis and the copper treated ones appeared to have made stronger root development. The biggest response to copper occurred on the gravelly sands nearest the laterite ridges.

When examined on November 2nd, 1938, the wheat had headed and grain was forming. The copper treated plots were even more obvious, as the wheat was standing up erect, level and strong throughout and was developing well-formed, well-filled heads. The other plots were very uneven, reflecting the variations in the soil. Whiteheads were particularly common on the poorer soil types.

Fig. 7 illustrates the appearance of sheaves harvested on December 6th and 7th from square yard quadrats taken across the eastern end of the plots (Row E, Fig. 6), where the maximum response was obtained and shows the effect of the various treatments on the range of soil types. Some response to copper is visible from plots 6 to 10 but is most marked on the gravelly sandy soils (plots 11 to 24).

At maturity, on the fairly small area of poorest gravelly soil, nearly all plants, except those treated with copper, failed to mature; the straw was a purplish grey brown and the glumes of the aborted ears pale.

Fig. 8.

Looking east and showing that the effect of copper is visible over the whole length of three of the plots. The cross shadows through the middle of the picture are due to the wave of the corn and a cloud effect. Mr. A. M. Stewart's farm, Wagin.

Photo.: Government Printer.

Examinations of the sheaths showed that while those from copper treated plots were yellow and had the normal pearly lustre inside, on all other plots on the gravelly sand the sheaths were commonly purplish grey in colour, and exhibited a characteristic purplish lustre on the inside.

Fig. 9 shows segments of stalks from copper and non-copper plots on this soil type.

On the better soil types of the lower part of the valley, where there was little or no apparent difference in yield, it was noticed that the glumes of the heads on the copper treated plots were brown while those on the others were pale.

Fig. 8 shows that some visible effect due to copper was apparent through the whole length of the plots irrespective of soil type. The apparent darkening was due to reduced reflection of the light from the more even and erect plants on the copper treated plots and, perhaps, in part to the darker glumes.

Yields were estimated by harvesting the plots and by taking square yard quadrats from five places in each plot. By this means indications were obtained of yield fluctuations according to soil type and are represented in Fig. 6.

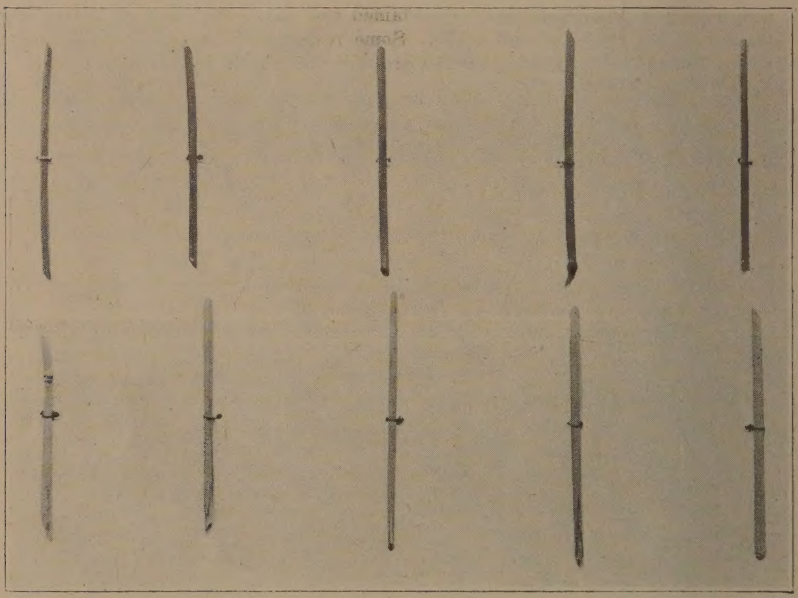

Fig. 9.

Segments of stalks of wheat at harvest time. Top: dark purplish grey discoloration from plots not receiving copper. Bottom: light golden straw from plots receiving copper.

Photo.: Government Printer.

(4) *Discussion.*

It will be observed from the harvest returns in Table 4 and in Fig. 6 and also in Tables A and B of the Appendix that the use of copper either with or without zinc and manganese caused improvement in yield of grain over the whole of the plots, and eliminated unevenness due to soil variations and the development of white and empty heads on the gravelly soils. The quadrats show that with copper on these poor gravelly soils, the yield of wheat grain is very good and at least equal to that on other soil types of higher fertility. Without copper, the yield of grain is very low and in accordance with previous experience.

There is a slight suggestion that ferrous sulphate and manganese sulphate may have been beneficial, especially on the poor gravelly soils of the south-east portion of the area.

TABLE 4.

Average yields of wheat at Wagin, computed from duplicate plots harvested and from 10 quadrats from each treatment:—

Treatment.	Yield of Wheat.	
	Harvester.	Quadrats.
	Bushels per acre.	Bushels per acre.
Superphosphate—1 cwt. per acre	17·5	17·2
Control (superphosphate—1 cwt. per acre, sulphate of potash—½ cwt. per acre)	20·5	19·1
Control plus 20 lbs. manganese sulphate	22·3	22·0
Control plus 20 lbs. ferrous sulphate	22·0	21·5
Control plus 20 lbs. copper sulphate	25·6	27·0
Control plus 10 lbs. zinc sulphate	19·8	19·4
Control plus 10 lbs. borax	17·4	18·1
Control plus 1 lb. cobalt chloride	20·6	21·0
Control plus 20 lbs. manganese sulphate, 20 lbs. copper sulphate, 10 lbs. zinc sulphate	22·2	28·9
Plots receiving copper (4)	23·9	28·0
Plots without copper (20)	20·1	19·6
Standard error of the mean difference between plots receiving copper and those without copper	± 1·80	± 1·06

TABLE A.

(Appendix.)

Yield of grain from the experimental plots at Wagin, estimated in bushels per acre from square yard quadrats:—

Plot No.	Treatment.	Row A. Bushels per acre.	Row B. Bushels per acre.	Row C. Bushels per acre.	Row D. Bushels per acre.	Row E. Bushels per acre.	Average. Bushels per acre.
1	Super only	5·8	19·9	2·6	27·0	29·4	16·9
2	Control—Super + potash ...	11·7	12·5	34·9	30·5	30·7	24·1
3	Control + manganese ...	19·8	12·5	22·7	37·0	25·9	23·6
4	Control + iron	16·7	12·2	28·3	36·6	31·0	25·0
5	Control	16·2	11·1	23·3	32·1	8·3	18·2
6	Control + copper	40·6	15·7	33·0	28·4	26·4	28·8
7	Control + zinc	18·7	11·9	32·3	21·7	20·3	21·0
8	Control	14·6	18·5	33·3	13·4	24·2	20·8
9	Control + cobalt	22·3	29·6	37·4	15·4	13·3	23·6
10	Control + boron	22·5	29·6	24·1	8·3	7·5	18·4
11	Control	16·8	25·4	27·1	16·4	7·6	18·7
12	Control + copper, manganese, zinc	27·1	26·2	34·4	30·1	27·6	29·1
13	Super only	22·5	42·4	10·2	11·8	1·3	17·6
14	Control	21·9	21·3	21·5	24·6	0·8	18·0
15	Control + manganese ...	21·6	28·0	24·9	20·0	7·2	20·3
16	Control + iron	16·0	27·9	23·2	13·4	9·5	18·0
17	Control	17·5	23·8	30·1	14·1	1·2	17·3
18	Control + copper	24·8	28·2	26·1	22·1	25·1	25·3
19	Control + zinc	20·9	30·1	15·3	19·3	2·8	17·7
20	Control	28·8	27·2	12·7	17·1	0·2	17·2
21	Control + cobalt	29·4	33·3	12·7	14·4	2·2	18·4
22	Control + boron	26·0	22·6	22·1	11·3	7·2	17·8
23	Control	36·6	24·1	17·6	10·8	3·9	18·6
24	Control + copper, manganese, zinc	39·0	29·9	14·2	20·6	39·7	28·7

TABE B.

(Appendix.)

Yield of total air dry material from the experimental plots at Wagin, 1938, estimated in cwts. per acre from square yard quadrats:—

Plot No.	Treatment.	Row A. Cwts. per acre.	Row B. Cwts. per acre.	Row C. Cwts. per acre.	Row D. Cwts. per acre.	Row E. Cwts. per acre.	Average. Cwts. per acre.
1	Super only	21·6	27·0	13·4	43·2	43·2	29·7
2	Control—super + potash ...	27·0	24·3	51·2	43·2	45·9	38·3
3	Control + manganese ...	29·7	19·0	37·8	59·3	43·2	37·8
4	Control + iron	24·3	19·0	43·2	54·0	43·2	36·7
5	Control	27·0	27·0	32·4	48·5	21·6	31·3
6	Control + copper	64·8	29·7	51·2	45·9	40·5	46·4
7	Control + zinc	29·7	27·0	48·5	32·4	37·8	35·1
8	Control	27·0	29·7	54·8	24·3	37·8	34·7
9	Control + cobalt	37·8	40·5	62·1	24·3	29·7	38·9
10	Control + boron	35·1	45·9	48·5	16·2	24·3	34·0
11	Control	29·7	37·8	48·5	26·9	24·3	33·4
12	Control + copper, manganese, zinc	40·5	43·2	56·6	43·2	35·1	43·7
13	Super only	32·4	62·1	21·6	26·9	13·4	31·3
14	Control	37·8	54·0	37·8	37·8	16·2	36·7
15	Control + manganese ...	37·8	45·9	43·2	35·1	24·3	37·3
16	Control + iron	35·1	43·2	45·9	21·6	29·7	35·1
17	Control	35·1	37·8	51·2	26·9	21·6	34·5
18	Control + copper	40·5	43·2	40·5	32·4	37·8	38·9
19	Control + zinc	32·4	45·9	32·4	32·4	18·8	32·4
20	Control	43·2	43·2	32·4	26·9	24·3	34·0
21	Control + cobalt	45·9	54·0	32·4	24·3	21·6	35·6
22	Control + boron	43·2	43·2	32·4	21·6	24·3	32·9
23	Control	56·6	37·8	35·1	29·7	32·4	38·3
24	Control + copper, manganese, zinc	64·9	43·2	26·9	32·4	56·6	44·8

(5) *Conclusions.*

(1) The use of copper sulphate has proved beneficial to the growth of wheat on some light lands in the Wagin district.

(2) On the poorest soil type (a gravelly sand) wheat failed to mature grain with superphosphate and sulphate of potash but produced a good crop when copper sulphate was used as an additional manure.

(3) Copper sulphate improved the apparent health and vigour of the wheat throughout the growing period.

(4) Other "minor" elements failed to produce substantial increases in yield on any soil type. Manganese and iron salts may have effected small increases on the poorest soil types.

(5) Borax and zinc sulphate interfered somewhat with germination.

(6) There is every indication that the poorer gravelly, sandy soils will give a payable response to small dressings with copper where previous crops of wheat, oats or barley have been unsatisfactory. Responses are less likely where a loamy subsoil occurs at a shallow depth.

(7) There is every likelihood that benefits from copper will be shown in improved quality of pasture and in the health of animals grazing on such types of country if they are unable to have frequent access to the better soil types.

The symptoms observed in the course of this experiment will enable diagnoses to be made elsewhere and offer an interpretation of previous crop failures on certain soil types. Experiments are being planned to ascertain more accurately the response to copper in relation to soil type, the most economical dressing to be used and the lasting value of the treatment.

IV.—THE EFFECT OF "MINOR" ELEMENTS ON THE GROWTH OF WHEAT IN OTHER PARTS OF THE STATE.

By L. J. H. Teakle and I. Thomas,
Department of Agriculture.

A number of experiments with other elements, in addition to superphosphate, have been carried out at several centres in the wheat belt. Sites were selected on account of unsatisfactory growth of wheat or interest in special soil characters.

(a) *In the North-Eastern Wheat Belt—Cleary.*

The patchy growth of wheat on certain brownish and pinkish brown soils of the north-eastern wheat belt had been observed for a number of years but no soil factor such as texture, profile, reaction or salinity could be correlated with the condition. In order to test the effect of minor elements under these conditions experiments were arranged in 1937 on Mr. B. B. Cooper's (two sites) and Mr. J. Blakeborough's properties north of Cleary.

The soils of the experimental areas on Mr. Cooper's property (Ninghan loc. 2972) were—(a) pinkish brown sands to loamy sands which carried cypress-pine (*Callitris glauca*), mallees, acacia scrub and scattered salmon gums in the virgin state, and (b) red brown to brown sands which, in the virgin state, had carried acacia scrub with a sprinkling of mallee and cypress-pine. On Mr. Blakeborough's property (Ninghan loc. 2935) the soils were a pinkish brown loamy sand showing some clay accumulation with depth. The virgin timber was cypress-pine with scattered mallees and interspersed with patches of acacia scrub.

On both properties the exploratory experiments, involving the following fertiliser treatments were laid down by Mr. W. M. Nunn, the Agricultural Adviser of the district. The plots were each 695 links long by 14.4 links wide (one-tenth of an acre in area) and each treatment was duplicated.

The fertiliser treatments detailed in Table 5 were used.

None of the treatments had any marked effect on the growth. Marked deepening of the green colour of the foliage was noted in early stages where the mixture of minor elements was applied and there was some impairment of germination. In October, inspection revealed no observable differences in amount or habit of growth on any plots.

Unfortunately, yields were obtained only from Mr. Blakeborough's plots and are reported in Table 5. Similar results were expected from the plots on Mr. Cooper's farm.

The possible deleterious effect of certain constituents of the "minor" element mixture may have been responsible for the lack of positive results and further trials with individual salts at lower rates seem justified.

TABLE 5.

Yield of wheat under various fertiliser treatments on Mr. J. Blakeborough's farm, Cleary. Sown on fallow, May 21st, 1937, using Totadgin wheat at the rate of 45 lbs. per acre:—

Treatment.	Yield		
	Per acre.		Per cent. of Control.
	Bus.	lbs.	
Superphosphate—1 cwt. per acre	10	52	100
Superphosphate—1 cwt. per acre ... ... Sulphate of ammonia—1 cwt. per acre	10	55	100
Superphosphate—1 cwt. per acre ... ... Sulphate of ammonia—1 cwt. per acre ... ... Sulphate of potash—½ cwt. per acre	9	28	87
Superphosphate—1 cwt. per acre ... ... Sulphate of ammonia—1 cwt. per acre ... ... Sulphate of potash—½ cwt. per acre ... ... Borax, sulphate of copper, zinc sulphate, magnesium sulphate, manganese sulphate, each 20 lbs. per acre	9	25	87

(b) *Salmon Gums Research Station.*

The unsatisfactory growth of wheat and oats on the Beete calcareous sandy loam or "kopi" is not correlated with known factors in all cases. Salinity often causes poor growth but many patches of non-saline areas of this type fail to mature a crop of cereal. Over a number of years it has been shown that stable manure, applied at the rate of 15 tons per acre with the biennial cropping programme, gives quite satisfactory yields, but manganese sulphate (56 lbs. per acre) failed to produce any beneficial effect. Likewise various "minor" elements applied to this soil type in 1938 failed to effect improvement of growth or yield of wheat.

Yields obtained from these experiments are given in Tables 6 and 7.

TABLE 6.

Effect of stable manure at the rate of 15 tons per acre with each crop and manganese sulphate at the rate of 56 lbs. per acre on the Beete calcareous sandy loam (kopi) on the Salmon Gums Research Station:—

Year.	Treatments (weights per acre).					
	Superphosphate—1 cwt.		Superphosphate—1 cwt. Stable manure—15 tons.		Superphosphate—1 cwt. Manganese sulphate—56 lbs.	
	bus.	lbs.	bus.	lbs.	bus.	lbs.
1932	6	56	9	36	6	8
1933	7	1	9	36	7	33
1934	5	36	12	16	5	52
1935	4	32	9	12	4	45
1936	4	19	10	21	5	9
1937	5	39	11	49	...	...
1938*	19	25	26	40	...	...

* Exceptionally wet year at Salmon Gums.

TABLE 7.

Yield of wheat on Beete calcareous sandy loam (kopi) on the Salmon Gums Research Station under various fertiliser treatments. Planted May 30th, 1938, with Gluyas Early wheat, sown at the rate of 45 lbs. per acre. All minor elements applied as salts at the rate of 20 lbs. per acre mixed with the superphosphate.

Treatment.	Yield of Wheat		
	Per acre.		Per cent. of Control.
	bus.	lbs.	
Superphosphate—1 cwt per acre	16	56	100
Superphosphate plus manganese sulphate	13	40	81
Superphosphate plus ferrous sulphate	14	40	87
Superphosphate plus zinc sulphate	17	16	102
Superphosphate plus copper sulphate	17	12	101
Superphosphate plus magnesium sulphate	16	12	96

It is possible that the calcareous nature of this soil interferes with the availability of essential minerals applied as fertilisers in the usual way. Spraying experiments are planned this year to test the effect of foliage treatment.

(c) *Wongan Hills Research Station.*

The Wongan Hills Research Station is used to study methods of developing good class sandplain country in the better rainfall areas of the wheat belt. In the drier years very creditable crops of wheat and oats are produced with the aid of superphosphate applied at the rate of about 120 lbs. per acre. Without superphosphate cereals will make no growth beyond that permitted by the reserves in the seed. With superphosphate the growth of cereals is apparently normal. No symptoms of malnutrition has been observed, except on gravelly bars.

The effect of other elements on the growth of wheat on the better soil types of the Research Station was explored in an experiment involving three series of 6 x 6 latin squares in 1938.

The surface soil at the site of the experiments consisted of a greyish yellow sand (pH 6.7) resting on a yellowish subsoil of sandy loam texture. Below 20 inches depth a little ferruginous gravel and red mottlings were observed and the pH was slightly lower. This soil type would be of considerably higher fertility than the gravelly sand, on which marked response to copper was obtained at Wagin (see Paper III, page 135).

Nabawa wheat was sown by hand and the fertilisers applied to the same rows. The fertilisers were applied as complete mixtures for each plots and, to ensure uniform application, the appropriate quantity for each row weighed into an envelope prior to sowing.

The plots sown were each 48 inches long by 7 rows wide (49 inches) and one square yard from the centre was harvested for yield computation.

During the growing season little reaction to the treatments was observed but borax appeared to interfere somewhat with germination.

Harvest returns are summarised in Table 8.

The results indicate that the "complete"† fertiliser at the rate of 1 cwt. of sulphate of ammonia, 2 cwts. of superphosphate and ½ cwt. of sulphate of potash per acre is not significantly superior to superphosphate alone.

† Containing nitrogen, phosphorus, and potassium.

TABLE 8.

Yield of Nabawa wheat resulting from treatments with "minor" elements at the Wongan Hills Research Station. Sown May 18 and 19, 1938. Harvested December 1, 1938. Control mixture: Sulphate of Ammonia—1 cwt. per acre; superphosphate—2 cwts. per acre; sulphate of potash—½ cwt. per acre. "Minor" elements: Manganese sulphate; copper sulphate, zinc sulphate, ferrous sulphate and magnesium sulphate—each 20 lbs. per acre. Borax—10 lbs. per acre.

Treatment.	Yield of Grain	
	Per acre.	Per cent. of Control.
Series I.—	bus.	
Control—N + P + K	33·9	100
Control plus copper sulphate	30·1	89
Control plus manganese sulphate	34·0	100
Control plus borax	25·9	76
Control plus zinc sulphate	18·9	56
Control plus magnesium sulphate	31·0	91
Difference necessary for significance (P = 0·05) = ±5·8 bushels per acre.		
Series II.—		
Control—N + P + K	27·8	100
Control plus ferrous sulphate	27·0	97
Control plus manganese sulphate, copper sulphate ...	21·4	77
Control plus manganese sulphate, copper sulphate, zinc sulphate	19·2	69
Control plus manganese, copper, zinc, magnesium and ferrous sulphates and borax	18·0	65
Control plus Mixture*	18·0	65
Difference necessary for significance (P = 0·05) = ±4·7 bushels per acre.		
Series III.—		
Control—N + P + K	31·4	100
Superphosphate only—2 cwts. per acre	26·4	84
Superphosphate plus borax	18·2	58
Superphosphate plus manganese sulphate	23·6	75
Superphosphate plus zinc sulphate	11·1	35
Superphosphate plus copper sulphate	21·0	67
Difference necessary for significance (P = 0·05) = ±5·8 bushels per acre.		

* Mixture contains sodium tungstate, cobalt chloride, antimony chloride, potassium iodide and nickel chloride each at the rate of 5 lbs. per acre.

None of the "minor" elements showed to advantage. Manganese sulphate, copper sulphate, ferrous sulphate and magnesium sulphate at the rate of 20 lbs. per acre, in addition to the "complete" fertiliser, did not significantly affect the yields. Zinc sulphate and borax each at the rate of 10 lbs. per acre proved harmful, as did all of the mixtures of "minor" elements.

The most outstanding result was the deleterious effect of zinc sulphate at the rate of 20 lbs. per acre. (Millikan (1938) in Victoria has reported improved yields from similar dressings in the Wimmera.) When used alone or mixed with other minor elements, zinc sulphate reduced the yield substantially, caused considerable to very severe shrivelling of the grain and induced a dirty, greyish colour on most of the injured grain.

Apparently zinc salts need to be handled with care and used in small applications with wheat on light soils. Reports of damage to potatoes have been received from Albany.

The mixture containing tungsten, cobalt, antimony, iodine and nickel also proved deleterious. The grain was shrivelled but no discoloration was observed.

It is obvious from these results that the use of minor elements for wheat cannot be expected to give improved returns except on certain soil types and under certain conditions. The observation of the crop symptoms—reaction to drought, tipping of the leaves, firmness of the rooting system, appearance of the head and discoloration of the sheaths, glumes, etc.—will give indications of possible deficiency of minor elements for cereals and will point to the need for experimentation. Where crops are healthy and vigorous, response in crop growth to minor elements is not to be expected.

(d) *Conclusions.*

1. The use of "minor" elements for the growth of wheat on soil types at Cleary, Salmon Gums and Wongan Hills failed to improve the yield.

2. Significant depression in yields resulted from the use of zinc sulphate, borax, and various mixtures of "minor" elements on the acidic sandy soils of Wongan Hills. Zinc sulphate was especially injurious.

3. At Cleary, a "minor" element mixture interfered with germination and yield of wheat but in the early growth stages caused the development of a deeper green colour than in the controls.

4. On the Beete calcareous sandy loam (kopi) at Salmon Gums stable manure gave substantial increases in the yield of wheat but no "minor" elements were effective.

LITERATURE CITED.

Adams, A. B. (1937)—Jour. Agric. West. Aust. 14: 283-284.
Baron-Hay, G. K. (1933)—Jour. Agric. West. Aust. 10: 85-91.
Bennetts, H. W. (1937)—Jour. Agric. West. Aust. 14: 247-250.
Carne, W. M. (1927)—Jour. Agric. West. Aust. 4: 515-519.
Dunne, T. C. (1938a)—Jour. Agric. West. Aust. 15: 120-126.
(1938b)— *ibid.* 15: 381-382.
Harvey, R. J. (1937)—Jour. Agric. West. Aust. 14: 386-393.
Hearman, J. (1938)—Aust. Forestry. 3: 22-27.
Hosking, J. S., & Burvill, G. H. (1938)—C.S.I.R. (Aust.) Bull. 115.
Kessell, S. L., & Stoate, T. N. (1938)—Forest Dept. West. Aust. Bull. 50.
Millikan, C. R. (1938)—Jour. Agric. Vic. 36: 409-416.
Morgan, E. T. (1938)—Jour. Agric. West. Aust. 15: 93-97.
Palmer, J. C. (1933)—Jour. Agric. West. Aust. 10: 70-72.
Pittman, H. A. (1935)—Jour. Agric. West. Aust. 12: 196.
(1936)—Jour. Agric. West. Aust. 13: 187-193.
Pittman, H. A., & Owen, R. C. (1936)—Jour. Agric. West. Aust. 13: 137-142.
Riceman, D. S., and Donald, C. M. (1938)—C.S.I.R. (Aust.) Pamphlet 78.
Teakle, L. J. H., Thomas, I., and Hoare, A. J. (1933)—Jour. Agric. West. Aust. 10: 340-354.
Teakle, L. J. H. (1938)—Jour. Roy. Soc., West. Aust. 24: 123-195.
Underwood, E. J., and Filmer, J. F. (1935)—Aust. Vet. Jour. 11: 84-92.
(1936)—Jour. Agric. West. Aust. 13: 199-201.
Underwood, E. J., and Harvey, R. J. (1938)—Aust. Vet. Jour. 14: 183-189.
Wickens, G. W. (1924)—Report of proceedings of Imperial Botanical Conference, London: 353-357
Wild, A. S. (1934)—Jour. Agric. West. Aust. 11: 223-225.

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SHEEP RUGGING EXPERIMENT.

I. THOMAS, Superintendent of Wheat Farming.
G. L. THROSSELL, B.Sc.(Agric.), Agricultural Adviser.

INTRODUCTION.

During recent years the question of rugging flock sheep has been a subject of considerable interest throughout Australia. It has been claimed by many agriculturists and farmers, particularly in South Australia, that rugging improved the value of the wool by preventing the entrance of dust and dirt which interfered with the free distribution of the yolk, thus causing the drying out of the tip of the wool, making it dry, harsh, and lacking in character. Further, in districts where plants having burry seeds like Burr Trefoil were prevalent, the rugs had the added advantage of preventing such seed pods from becoming attached to the wool and so further reducing its value. It was further stated that the increased value per lb. in the wool was more than sufficient to pay for the cost of rugging, and so was an economical proposition.

In view of the statements made and the absence of any particular experimental data in this State, it was decided in 1936 to institute experiments at three of the Research Stations in the Wheat Belt to obtain definite information on the question.

The idea of rugging flock sheep apparently originated in South Australia. In 1935 Scott (1) drew attention to the results of experiments conducted at the Turretfield Experiment Farm in 1934. It appears that these experiments were conducted under dusty conditions as Scott stated that the dirt had fouled the wool on the back down to the skin and had destroyed the character of the wool, making it harsh, trashy and without life. It was stated that the increase in wool values due to rugging amounted to 2s. per head. Since then, other reports on recent investigations on the subject have been published. In experiments conducted by Montgomery (2) at Albury, N.S.W., heavy burr and dust contamination were avoided. He concluded that rugging was very unlikely to be economical under conditions of low rainfall and moderate temperatures, in the absence of burr and dust. Further experimental work was necessary to show what economical returns would be obtained where heavy contamination with dust or burr was encountered. The experiments of Blumer and Cotsell (3) were carried out under winter conditions, the experimental sheep being rugged in May, having been shorn the previous October. The authors concluded that rugging had no commercial value in the five winter months in New England (N.S.W.) but pointed out that the results did not apply to any benefits which might result under burry and dusty conditions. The experiments conducted at Condobolin (N.S.W.), reported by Elliott (4), although somewhat limited, indicated that there was a difference of approximately 50 per cent. in the per lb. value of the fleece wool from the rugged sheep. When, however, the difference in the average fleece weight was considered (7.75 to 9.93 lbs.) there was only an average increase of 2½d. in favour of the rugged sheep. Apparently conditions were very dusty in these experiments. Peirce (5), reporting on experiments at the Waite Institute (S.A.), stated that rugging had no effect on the milk production of the ewe or upon the early growth of the lamb.

DETAILS OF W.A. EXPERIMENTS, 1936-1938.

After dipping in 1936 at the Chapman, Salmon Gums and Yilgarn Research Stations, twenty plain-bodied four-tooth Merino ewes were selected and divided into two groups, by drafting off alternate sheep. One group was rugged with a light duck rug of local manufacture, costing 15s. a dozen, and the other group was not rugged. Each sheep carried an individually numbered ear tag. Both groups were

run together with the main flock, which was kept under the ordinary flock conditions at the Research Stations, which must be considered typical of the farming areas of Western Australia, and included grazing on fallowed land at various periods. Such conditions are somewhat dusty at times, and do produce a dry dusty tip in the wool. Severe dust storms, however, are not general in these areas. There is very little burr trefoil at either Yilgarn or Salmon Gums, and is only present in the wool at Chapman in years of heavy rainfall. During the summer months when feed was scarce, considerable trouble was experienced owing to the rugs being damaged by the bush and scrub, and it was necessary from time to time to yard the sheep to adjust and repair the rugs. Towards the end of May, *i.e.*, at the commencement of the winter, the rugs were removed, as it was not considered necessary to keep them on after the seasonal winter rains commenced. When the rugs were removed the wool of the rugged groups at all stations looked much cleaner, heavier in condition and brighter in appearance, and at Yilgarn an improvement in both the condition of the wool and the sheep could be noticed. The month of July, however, was an unusually dry one and dusty conditions were prevalent so that at shearing time little or no difference could be detected between the two groups at any station. No deaths occurred and none of the experimental sheep were fly-struck, while there was no significant difference regarding the incidence of lambing in either group. From Table I. it will be seen that there was no significant difference in the average wool yield per head.

TABLE I.

Station.	Date Rugged.	Date Rugs Removed.	No. of Days Rugged.	Average Yield of Wool per Head.	
				Rugged.	Not Rugged.
	1936.	1937.		lbs.	lbs.
Chapman	Nov. 3	May 17	195	9·0	10·0
Salmon Gums	Dec. 19	May 27	159	12·2	12·1
Yilgarn	Oct. 15	May 28	225	9·5	10·1

The wool from each group was classed and forwarded to Messrs. Elder, Smith & Co.'s Wool Store, Fremantle, where it was valued by the manager of the Wool Department (Mr. K. Hodge). He reported that there was practically no difference in regard to the presence of dust or in the density of the two groups from Yilgarn, and valued the rugged wool at ½d. to ¾d. per lb. (approximately 4 per cent.) more than the unrugged wool. The unrugged wool from Chapman looked better grown, longer in staple and more robust and drier, and was valued at 1d. to 1½d. per lb. (approximately 8 per cent.) more than the rugged wool. The wool from Salmon Gums exhibited little or no difference in tip, in regard to amount of dust, appearance or value, and on the wool floors, both lines would have been lotted together. The rugged wool was slightly denser, more robust and heavier in condition, but there was slightly more money, amounting to ½d. per lb. in the unrugged wool, as the skirtings were slightly drier.

It must be admitted that the conclusions which can be drawn from this, the first year's experiment, must be limited but they indicate that under the conditions prevailing at these Stations, rugging did not increase the value of the wool return. Owing to the limitations of the 1936-37 experiments, it was decided to continue the investigation, enlarging each group to 50 sheep, using improved and better quality rugs and keeping the rugged section rugged from dipping time to the following shearing, *i.e.*, approximately eight to nine months.

The Yilgarn sheep comprised 100 even type full sound mouth merino ewes, which were drafted off alternately into two groups of 50 each. The Chapman sheep comprised 34 four-tooth, 30 six-tooth and 36 full but sound mouth merino ewes which, after mixing, were divided into two lots by alternate drafting. The Salmon Gums sheep comprised 35 two-tooth, 5 four-tooth, and 10 six-tooth merino ewes in each group. After rugging and ear tagging, the experimental sheep were run with the main farm flock as in the previous year.

At both Chapman and Yilgarn considerable trouble was again experienced through the rugs becoming damaged and torn by the scrub. Sheep which were found without rugs were excluded from the experiment, and wherever possible torn rugs were repaired. Where necessary very badly torn rugs were replaced by new ones. During the course of the experiment the total number of rugs used for the 50 experimental sheep at the respective stations was, Salmon Gums, 53, Yilgarn 80, and Chapman 88. The number of sheep excluded on account of loss of rugs was four, viz., one at Chapman and three at Salmon Gums. The number of deaths recorded was twelve, the numbers in the rugged and unrugged groups being respectively, Chapman nil, 1; Salmon Gums 1, nil; and Yilgarn 4, 6.

Blowflies were more prevalent in this experiment. At Chapman four of the rugged group and five of the unrugged group were struck, whilst at Yilgarn the respective figures were two and nil and Salmon Gums 13 and 11. Those struck at Yilgarn were excluded from the experiment as it was necessary to remove the rugs.

At Chapman 94 per cent. of the rugged and 92 per cent. of the unrugged ewes produced lambs and at Salmon Gums the respective figures were 60 per cent. and 70 per cent., the smaller number of lambs being accounted for by the number of maiden ewes in the groups. At Yilgarn when the ewes were crutched it was recorded that most of them were in lamb. Later, owing to the adverse season, the sheep were yarded as little as possible, and hence a detailed record of the individual lambing was not possible. It is concluded that rugging did not interfere with the mating or fertility of the ewes or cause any difficulty at lambing.

After shearing, the wool was carefully classed into its appropriate classes, each group and class being kept separate. As before, it was forwarded to Elder, Smith & Co.'s Fremantle Store and each class valued individually by Mr. K. Hodge (Manager, Wool Department). The wool yield and values per head are shown in Table II.

TABLE II.

Station.	Date Rugged.	Date Shorn.	Days Rugged.	Rugged.				Not Rugged.			
				No. of Sheep.	Total Wool Yield.	Average Wool Yield per head.	Value of Wool per head.	No. of Sheep.	Total Wool Yield.	Average Wool Yield per head.	Value of Wool per head.
	1937.	1938.			lbs.	lbs.	s. d.		lbs.	lbs.	s. d.
Chapman	Dec. 14	Aug. 23	253	49	443	9·04	7 6	49	481	9·82	7 11
Yilgarn	Dec. 10	Sept. 6	271	44	370	8·41	6 5	44	366	8·32	5 9
Salmon Gums	Dec. 9	Sept. 21	287	46	430	9·35	8 10	50	478	9·56	8 11

Such small differences are most unlikely to be significant, but even in the case of Yilgarn, an apparent improvement of 8d. per head would not be an economic proposition when the cost of the rugs and the time employed in adjusting and repairing them is taken into consideration.

It is desired to acknowledge especially the assistance rendered by Mr. K. Hodge, manager of the Wool Department of Messrs. Elder, Smith & Co., who valued the wool from the experimental sheep and Messrs. F. Gishubl, J. H. Moulton and W. Human, Managers of the Chapman, Salmon Gums and Yilgarn Research Stations respectively, who carried out the field details of the experiments.

SUMMARY.

A brief review of the literature regarding the rugging of sheep is given.

Experiments conducted at the Chapman, Yilgarn and Salmon Gums Research Stations from 1936 to 1938 are described. It is concluded that (1) the rugging of flock sheep in the farming areas of Western Australia will not increase the value of the wool clip, and is therefore not warranted; (2) rugging, however, did not interfere with the mating or fertility of the ewes, nor cause any difficulties at lambing time.

REFERENCES.

(1) Scott, R. C. (1935) Jn. Dept. of Agric. S.A., 39, No. 4, p. 534.
(2) Montgomery, I. A. (1938) Jn. C.S.I.R., 11, No. 3, p. 221.
(3) Blumer, C. C. & Cotsell, J. C. (1938) Agric. Gazette of N.S.W. 49, No. 4, p. 188.
(4) Elliott, E. H. (1939) Agric. Gazette of N.S.W., 50, No. 2, p. 65.
(5) Peirce, A. W. (1938) Jn. C.S.I.R., 11, No. 3, p. 229.

FIRST EARLY SUBTERRANEAN CLOVER.

NOTES ON ESTABLISHMENT.*

H. G. Elliott, Agrostologist; T. C. Dunne, Agricultural Adviser.

No more suitable pasture species for the areas having a rainfall of 16-25 inches per annum has been yet found than First Early ("Dwalganup") subterranean clover. The plant meets many requirements in that not only has it been successful for grazing but it allows hay and silage of excellent quality to be conserved. This is of great importance in providing for sheep a summer feed which is not only a concentrate but which is relatively inexpensive. The large amount of seed formed underground in burrs forms another nutritious food reserve. Under favourable conditions, even when a hay crop has been taken off, some hundreds of pounds of seeds per acre may be found under an established sward. The burrs containing the seed can easily be brought to the surface with a cultivator or scarifier, when they will be readily eaten by sheep. The clover is further recommended by virtue of its value as a soil renovator and its inclusion as a unit in crop rotation in the areas mentioned will undoubtedly result in the production of better cereal crops. Its utilisation for this purpose has already been recommended (2).

During the last five years there has been a rapid expansion of the growing of the first early variety of subterranean clover in the 16 in. to 25 in. rainfall area and it is confidently expected that there will be a further large increase in the areas sown to this clover for sheep farming. A publication dealing with subterranean clover generally is already available (1) but for those without previous experience with the early strain some directions for establishment are given.

Seed and Strain.

In procuring seed for areas under review, only certified First Early ("Dwalganup" subterranean clover should be considered. This is the earliest flowering strain at present available and the only one with which success can be assured with a rainfall of less than 25 inches per annum. Many farmers in previous years have made efforts to introduce subterranean clover but their attempts have been nullified by the wrong strain of seed having been sown. At Muresk this early strain flowers about the second week in August and seed is formed while the soil is still moist enough for the burrs to be buried. For maintenance and improvement of the pasture it is essential that the clover be able to bury the seed.

So important has the question of securing the correct strain become that in 1935 the Department of Agriculture introduced a system of certification for the First Early ("Dwalganup") strain of subterranean clover and prospective buyers should insist on obtaining certified seed. During the last few years many other strains of early subterranean clover have been located, the most important of these being Mulwala, Nangeela and the Cookernup white seeded. Trials are being conducted at present with these.

Where to Sow.

One of the advantages of subterranean clover lies in its ability to thrive on soils which have been depleted of fertility by cropping. Not only does it thrive under these conditions but it renews the fertility of such areas. When selecting areas for sowing it is best to begin on paddocks which show the need of an extended period of rest before reverting to cereal cropping. Less competition from other plant species will be experienced and a good sward of clover will soon be established.

The clover does well on a variety of soils. Particularly satisfactory results are secured on light sandy soils which are often not productive with other crops. Excellent results are also secured on heavier soils, particularly where the rainfall is good. Where the rainfall is lower, *i.e.*, approximating 16 inches per annum, it will probably be best to begin on the lighter soils as there is a possibility of the surface of the heavier soil becoming hard before the seed can be buried. On the other hand, it may be possible to obtain good results on sandy soils with an annual rainfall of less than 16 inches. During the last two seasons promising results have been observed in the 12 in. to 16in. rainfall belt on sand-plain country.

Time of Sowing.

This seed should not be sown early in dry soil as there is danger of germination with a light shower and subsequent dying of the young seedlings should a dry spell follow. It is necessary to await the arrival of the reliable winter rains which normally occur early in May. This will allow plenty of time for satisfactory first year growth and seed formation.

Cover Crop.

Subterranean clover may be established successfully with or without a cover crop. Sowing with a cover crop such as oats, which has been used for grazing off or to be harvested for hay or grain, has much to recommend it, in that the clover is only very little grazed in the case where the feeding off of the cover crop occurs, and is protected from grazing where it is to be left for hay or grain, with the result that the clover will multiply considerably during the first year, without loss of time.

* Revised from the article of the same name by T. C. Dunne, published in this Journal for March, 1935, pages 81-84, and which was subsequently issued as Leaflet No. 442.

Another advantage of sowing with a cover crop is that in most cases a reasonable seed bed is prepared prior to sowing, and that a considerable amount of fodder is produced during the first year of establishment.

The use of a cover crop, however, depends to a large degree on the rainfall of the area, and the type of soil on which it is intended to sow the seed. In the lower rainfall areas, with light sandy soils, a light cover crop can be used successfully. On the heavier types of soil, however, a cover crop is not recommended.

A seeding rate of 2 to 3 lbs. of clover seed per acre should be incorporated with the cover crop, or 4 to 5 lbs. per acre when clover only is sown. In the better rainfall areas cover crops can be used successfully, and a clover seed sowing as light as 1 lb. per acre may sometimes be sufficient to introduce the plants where a cover crop is used, but it takes somewhat longer for the clover to spread and completely cover the ground. It must be emphasised that an excellent germination alone, with the correct method of sowing must be utilised for this light rate of seeding to give satisfactory results. Where no cover crop is used, it is advisable to sow 4 to 5 lbs. of seed in order to obtain a certain amount of feed in the first year.

Rate of Seeding.

Seed production by this clover is so prolific, that it is often found more economical to sow the seed lightly, and let it multiply in the field than to sow heavily enough for a complete cover in the first year. Where seed can be obtained cheaply, or is cleaned on the farm, rates as high as 8 lbs. per acre have been used with success. Experiments have shown, however, that 4 lbs. per acre is about the maximum for economical establishment.

As stated under the section of cover crop, varying rates of seeding can be utilised, and where the cover crop is used, 2 to 3 lbs. per acre of clover seed is quite satisfactory. If a cover crop is not used, 4 to 5 lbs. of seed per acre is recommended.

By nature, subterranean clover has a fairly high percentage of hard seeds, *i.e.*, seeds which do not germinate during the first season but will germinate in later years. In the process of extracting the seed from the burrs, however, most of the seed is scratched and the percentage germination is considerably increased.

While it is not advisable to buy clover burr for fear of introducing insect and plant pests, it is a good practice to collect burr from any area on the farm already under subterranean clover and thus to sow other areas. The percentage germination of this unscratched seed would be fairly low and a heavier seeding would be necessary. At least enough burr to give about 8 lbs. of seed per acre should be distributed. Good clean burr which is free from stems, stones and small sticks should give about one-quarter of its weight as clean seed. When raking for burr, the sample obtained may contain, if not cleaned, only about one-tenth of its weight as clean seed.

Methods of Seeding.

Results at Muresk (3) on lighter types of soils showed that with subterranean clover seed the best germinations were obtained with the seed sown at the ¼ in. and ½ in. depths. The germination at 1 in. was satisfactory but the number of plants from deeper plantings showed a considerable decrease and at 2 in. failure resulted. Apart from the germination, the time factor was important. The results showed that the seed planted at ¼ in. had practically given a complete seedling appearance in seven days, whereas it was 17 days before a reasonable number of plants appeared from the 1 in. sowings.

Covering of the subterranean clover seed with soil is essential. Results show that where the seed is dropped on the surface of cultivated soils a certain amount of covering is obtained, but it is probable that a large proportion of the seed obtains no covering with consequent poor establishment. The result is of more importance in relation to the establishment of clover on uncultivated paddocks. Actually almost total failures have been observed where clean seed was broadcast on the surface of bare uncultivated paddocks without any effort being made to give a light covering.

When a cover crop is used it is safest to make the sowing of the clover seed separate, either using a small seeds box attachment on the drill or "combine," broadcasting the seed by hand or through a broadcaster. The seed may be covered in the case where the small seed box attachment is used by tying the tubes from the box back so that a light covering is given by the rearmost tynes of the "combine." Alternatively, covering may be obtained by following with a light harrow and, where it is sown through a topdresser or drill, a chain dragged behind will usually give enough cover.

In order to spread the small amount of seed evenly it should be mixed with sand or, if this is not easily available, with superphosphate. If superphosphate is used, however, it should be mixed with the seed immediately before sowing, as if left in contact with the seed for any length of time it may have a detrimental effect on germination.

Satisfactory germination has been secured in some instances by mixing the seed with the superphosphate and sowing through the drill with the cover crop. Failures, however, have been recorded, presumably through the seed being buried too deeply. Broadcasting the seed separately or using the small seeds box attachment is recommended as being the safer method to adopt.

Where no cover crop is used, some effort to provide a light covering of soil for the seed as stated above will be well repaid by better germination. This is especially the case on lighter soils or where the soil is quite devoid of any material such as dead grass which would help the seedlings to take hold. A light harrowing should be given before sowing and covering provided as suggested above.

When clover burr is used, there does not appear to be the necessity for providing a covering of soil such as is required with clean seed. The burrs themselves tend to take hold of the soil particles and to become partly buried with the early rains. For this reason it is doubtful whether any cultivation given prior to sowing clover burr would be profitable.

Inoculation (4).

All plants belonging to the legume family, which includes clover, peas, beans, etc., have the ability to use atmospheric nitrogen for growth but only when the proper bacteria, which vary for different groups of plants, are present. The bacteria, which are present in the soil where cluster clover, hop clover and other common clovers (but excluding burr trefoil) are growing, are those needed by subterranean clover, and on such areas satisfactory results will be secured. In some cases, however, these clovers are not present and inoculation of the seed with the necessary bacteria is advisable. For this purpose bottles containing bacteria for inoculation, together with directions for use, are provided by the Department of Agriculture at a nominal cost.

Seed so inoculated should not be mixed with superphosphate prior to planting as the superphosphate injures the bacteria. The best practical methods of sowing are those in which the inoculated seed is sown at the same time as the superphosphate, but where no contact is made, as with the small seeds box attachment on a drill or "combine," or where the contact between the seed and fertiliser is only

momentary, as is the case when the seed is sown through the grain section of a drill or "combine." It is essential that the ground should be wet at the time of sowing.

Fertiliser.

Fertiliser, in the form of superphosphate, is essential to the success of subterranean clover. The superphosphate should be applied at the time of seeding and thereafter each autumn. When the pasture is established the best time for application is with the advent of the first reliable rains. However, a heavy cereal cropping programme often prevents much attention to pastures at this time so that it may be necessary in many cases to apply the superphosphate earlier in the season on the dry land.

Previously it was recommended to apply from 90-112 lbs. of superphosphate per acre. However, recent experiments have shown that not less than 112 lbs. of superphosphate per acre should be applied annually and in many cases further profitable results have been obtained from applications as high as 180 lbs. per acre.

Management.

The use of a cover crop almost obviates the need for careful management in the first year, especially if the crop is not grazed. By the time the crop is removed the clover has matured and the seeds for the following year's stand are buried. Allowing formation and burying of as much seed as possible in the first year is an important factor in successful establishment.

More care is needed where no cover crop is used. The paddocks should not be grazed until some lateral development of the young clover plants has taken place. Again, at the time of seeding, stock should be kept away until the seeds have been buried. Subterranean clover, when dry, provides good feed, and grazing at this stage can have no detrimental effect on the subsequent pasture.

General.

Prospective growers are warned against expecting too much from early subterranean clover in the first year. At the rate of seeding suggested, only a thin stand is produced and the plants are characterised by long runners and scanty foliage. At this stage it appears rather unattractive. It must be remembered, however, that this habit of growth enables the clover to spread and eventually cover the ground. A vigorous plant in the open may have a number of runners up to three feet in length radiating from the centre. Burrs containing three or four seeds may be formed about every three inches along the stems. Such a plant could easily produce over one hundred seeds for the thickening of the stand the following year. When the stand becomes thick, the plants are forced into more upright growth and a mat of leafy pasture is obtained in the second or third year.

References.

(1) Leaflet No. 225: Subterranean Clover—C. A. Gardner and T. C. Dunne. Reprint from "Journal of Department of Agriculture," Vol. 10, No. 1, March, 1933.

(2) Leaflet No. 414: A Modified Rotation for the Wheat Belt—T. C. Dunne and F. L. Shier. Reprint from "Journal of Department of Agriculture," Vol. 11, No. 2, June, 1934.

(3) "Journal Department of Agriculture, W.A.," Vol. 13, No. 1, 1936: Seeding Experiments with First Early Subterranean Clover—T. C. Dunne.

(4) "Journal Department of Agriculture, W.A.," Vol. 16, No. 1, 1939: The influences of methods of planting on the effective Inoculation and establishment of Subterranean Clover—W. P. Cass-Smith and H. A. Pittman.

THE INVESTIGATION OF "FALLING DISEASE" OF CATTLE IN THE SOUTH-WEST.

By H. W. BENNETTS, Veterinary Pathologist, and H. T. B. HALL, Veterinary Officer.

Introduction.

A disease of cattle characterised by a localised distribution, seasonal occurrence and by sudden death without previous signs of illness, has been known for some years in the Busselton and Northcliffe districts.

It was first reported to the Department in 1929.

Preliminary investigations were carried out by Veterinary Officers A. F. Flood and E. F. Twaddle and their observations and records have been most helpful.

No systematic investigation, however, was possible until 1937, when one of us (H.T.B.H.), was stationed in the Busselton district as a field officer for the purpose of studying the disease. Following his resignation about the end of 1938, Veterinary Officer R. Harley took over the work in the field. During 1938, the Assistant Animal Nutrition Officer, A. B. Beck, commenced chemical work which will be reported in detail at a later date.

During the last two seasons the Agricultural Bank has greatly assisted the investigators, both by providing locations and animals for experimental work, and by the co-operation of their officials in the Busselton district.

The purpose of this article is to describe a disease, which does not appear to have been reported from outside the State, and to give some account of the results of the investigations up to the present time.

Distribution and Economic Importance.

The area affected is a belt of coastal country in the south-western corner of the State. On the west coast it extends from Wonnerup in the north to Forrest Grove in the south and inland for a distance of about 10 miles.

Almost without exception only occasional losses have been reported from the older settlements along the coastal fringe. The disease occurs predominantly further inland on country which is largely devoted to Group Settlement. There is a further occurrence in the Northcliffe groups adjacent to the south coast.

The disease constitutes a grave economic problem as the group settlers, dependent almost entirely on dairying for a living, are ill equipped to stand the loss of income and capital resulting from the death of a number of cows, generally those just coming into profit.

Type of Country Affected—Pasture.

In the Busselton district the predominant timber, in the affected area, is jarrah or marri (red-gum). The soil types vary considerably, losses having been investigated on heavy loam, gravelly soils and on grey sandy soils—in general there is a yellow clay subsoil. The affected country at Northcliffe is similar.

The group settlement holdings consist of about 150 acres, of which—at the present stage of development—approximately one-half has been cleared and carries improved pasture. The average herd consists of 20 milking cows.

The holdings were originally sown with subterranean clover. This initially did well and good stands still persist on some locations. Commonly, however, for reasons not yet fully understood, this clover has "stalled" and its place has been taken

by drooping flowered or "reverse" clover which grows luxuriantly throughout, particularly on wet locations. This natural change has been going on for some years and almost without exception falling disease has occurred only on locations which have "reverted" to drooping flowered clover. On affected holdings during the period of the year—notably in September and October—when the disease occurs, the pasture tends in the main to be a prolific growth of this clover associated with suckling clover. Grasses come into prominence later in the year and mortality ceases about the time when grass begins to predominate over the clover. The following are then observed:—Yorkshire fog, sweet vernal, silver grass, spear grass, rye grass, barley grass; capeweed, flatweed and sorrell are also common. On wetter portions lotus major, paspalum and kikuyu grow luxuriantly and pastures may be green throughout the summer months.

Pastures are top-dressed annually with superphosphate, usually about 1-2 cwt. per acre—without this dressing they revert to Yorkshire fog, hop clover and the aforementioned weeds.

Occurrence of the Disease.

The occurrence varies from year to year, both as regards areas affected and individual properties.

On some locations deaths have been reported annually for the past six or seven years. From 5-40 per cent. of the herd may succumb, generally within a few weeks of the first appearance of the disease. Most of the stock carried on the group settlement holdings have been bred in the district. In some cases affected animals have never been off the locations on which they were born; most of the cows, however, have been transferred at some time or other from one location to another in the same district. There is no evidence of the disease being brought on to a property with an animal transferred from an affected location.

Season.

The disease is definitely seasonal: mortalities may occur from July to December, but only occasional deaths are reported earlier than September or later than October.

Species, Sex, Age, Condition.

Cattle only are affected. No deaths of a similar nature have been reported in horses, pigs, or in the comparatively few sheep which are carried in the district.

Sex.—The occurrence of falling disease has been confirmed only in cows, although a number of sudden deaths in bulls have been reported.

Age.—The disease appears to be more common in aged cows, although animals of any age from 12 months upwards, may be affected.

Condition.—Agricultural Bank records of reported cases of the disease indicate that cows in calf or recently calved are most susceptible. Of 16 cows examined in 1937, however, three were in calf, four had just calved and six were milking cows not in calf (no breeding history in three cases). Affected animals are generally in fair condition.

Symptoms.

"Falling disease" or "sudden death" is most frequently observed when cows are being brought in to be milked, are standing in the bail, or are being driven out to paddock again. In some cases the cows have actually fallen on the milker. Deaths also occur when cows are at pasture but are not observed very often. A cow,

apparently in normal health, suddenly bellows, throws up its head and falls dead. Death frequently appears to be instantaneous. Sometimes the animal falls and struggles feebly on its side on the ground for a period varying from a few seconds to five minutes. In these cases of longer duration intermittent bellowing, running movement of the legs and attempts to regain an erect posture are also noticed. Finally the animal lies stretched out with head back and dies.

The following is a settler's account of a death witnessed by him:—

> When I first started bringing the cows home she was perfectly normal and grazing with the rest. I had got them about half way home when she stopped and started swaying on her feet, she seemed to be paralysed and could not move, she also seemed to be forcing water from herself. She then started to stagger with her head down, as if she was drunk, after that she fell flat on her side and rolled completely over with her back downhill, her legs and neck stretched out straight and her legs quivering. She gave a few groans, her back legs doubled up and she turned partly over on her back, her legs then went straight again and she was dead. She died within one minute and a half of when she started to sway.

Rarely an animal may show symptoms for 24 hours or more, intermittently pivoting with the head down, before dying suddenly in the typical manner. Three such cases were observed by H.T.B.H.

Post Mortem Appearances.

The post mortem examinations of 25 typical cases by H.T.B.H. showed the following as the most constant and striking features:—The rectum and vagina are protruded somewhat, even immediately after death and are injected with blood. The carcase "blows up" very quickly. Internally the tissues are injected with blood, the liver is large and friable and the spleen large, dark and pulpy. The lining of the fourth stomach and small bowel is dark (congested). The appearances are not very characteristic. Microscopic examination of organs, however, shows definite and typical changes which enable one to say definitely that a cow has died of falling disease—the kidney changes are characteristic and the spleen and, to a less extent, liver and kidneys show extensive deposits of iron (hemosiderin).

Experimental Investigations.

In addition to the examination of affected animals referred to above, an extensive series of experiments has been carried out with a view to determining the cause of the disease. It is proposed to summarise them only briefly here.

Attempts were made to reproduce the disease by inoculating experimental cattle with blood from affected animals and by drenching them with stomach and bowel contents from falling disease cases. The results were negative.

A careful search was made for any bacteria which might be causing the condition—again the result was negative. It did not appear, therefore, that any germ or other infectious agent was responsible.

Surveys made by the Government Botanist (C. A. Gardner) and the Acting Government Botanist (G. R. Meadly), to quote from a departmental report submitted by the latter, "did not reveal any plant that could be strongly suspected of causing 'falling disease.' The only species present in quantity and common to all areas was drooping flowered clover."

In order to make sure, however, that a poisonous plant was not responsible for the disease, the only three considered suspicious—including Emu bush (*Podocarpus drouyiana*)—were tested by feeding them to experimental cattle. Feeding tests

were carried out in 1936 by E. F. Twaddle and in 1937 by H.T.B.H. Results were entirely negative.

Although drooping flowered clover is considered a good pasture plant the constant association suggests that it may in some way contribute to the occurrence of the disease and it will be regarded with some suspicion until further investigations are completed.

It being known that some pasture plants, including clovers, may at times become dangerous to stock owing to development of prussic acid, pastures and animals dead of the disease were tested for this poison. The result was negative.

Anaemia and Mineral Deficiency.

Microscopic examination of blood from fresh cases of the disease investigated in 1937, indicated that affected animals had suffered from anaemia.

Following this discovery during 1937 and 1938 extensive examinations of blood of cows in affected, and to a less extent in non-affected herds, have been carried out. These showed that many cows in the herd, despite apparent normal health, were affected with a severe anaemia. This anaemia occurs during the period of the year when cows are susceptible to falling disease and natural recovery begins about the same time as losses from the disease, cease. The condition of the blood returns to normal during November and December.

The occurrence of severe anaemia in milking cows coincidently with the period of susceptibility to falling disease appears to be very significant. There are indications that this anaemia and the presence of iron accumulations in the organs of animals dead of falling disease might be due to a mineral deficiency or deficiencies.

During 1938 an experiment was carried out at the Jindong Bank Depot for the purpose of determining any relationship between falling disease, anaemia and mineral deficiency. Five cows were given daily a "complete mineral supplement" (iron, copper, cobalt, manganese, nickel, zinc) and five cows which received no minerals were kept as controls. The control group showed definite anaemia during October, whereas the group receiving minerals remained normal throughout.

No cases of falling disease developed in the experimental herd, possibly on account of the comparatively poor growth of clover in the pasture that season.

The occurrence of diseased conditions in young animals* and the type of anaemia occurring in the district suggested the probability of copper deficiency in the affected area.

During 1937 an experiment was carried out with a view to determining the effect of feeding copper supplement to anaemic cows. Unfortunately this was commenced late in the season and a natural recovery (seasonal—see earlier) in the portion of the herd not receiving copper obscured the results.

In the past season determinations carried out by the Assistant Animal Nutrition Officer and which will be reported in detail later, indicate that the copper status of both animals and pastures in the affected area is well below normal.

Further and more extensive experiments are now being undertaken in order to determine the relationship of mineral deficiency to the anaemia and to falling disease.

* It was known from the earliest days of settlement that much of the coastal fringe—Busselton district—was "unsound" for breeding stock—lambs developed ataxia ("rickets") and foals and calves were unthrifty, poorly grown, "stood up on their toes" and developed malformed legs. Ataxia has been shown to be due to copper deficiency and the other conditions are ascribed to a similar cause.

Recently Harley has ascertained that similar conditions are now quite common in the "falling disease" area.

It appears extremely unlikely that a mineral deficiency by itself could be responsible for sudden death. On the other hand, it appears possible that mineral deficiency and anaemia might predispose to falling disease.

This study, associated with further blood examinations, and attempts to reproduce the disease, will constitute the main lines of investigation projected this season.

Recommendation.

It is impossible at this stage of the investigation to make any definite recommendations for the control of the disease.

At the same time, in view of the serious losses occurring annually and the probable long duration of the investigation we feel justified in making a suggestion.

There is much evidence that stock in the "falling disease" area are affected with a deficiency of copper and/or other minerals, and we are of the opinion that this may in some way be associated with the disease.

Field observations indicate—as one would expect—that a limonite lick (Denmark No. 1) which provides a fairly complete mineral supplement, beneficially affects the health and condition of the blood of milking cows receiving adequate quantities.

It is suggested, therefore, that settlers in the affected area would be well advised to feed Denmark No. 1 lick to their milking cows, particularly during the months of May-December: a daily dose of 1½ ounces should be adequate.

Acknowledgment.

The authors desire to acknowledge their appreciation of the assistance afforded by the Agricultural Bank in providing locations and animals for experimental work. The officials, notably those in the Busselton Branch, assisted in many ways and were always courteous and helpful. Mr. J. M. Nelson, Dairy Supervisor, Vasse, was also very helpful.

We are indebted to many settlers for reports of cases and for making their herds available for blood determinations. Mr. F. Wilkinson of Metricup, in addition, further assisted by looking after experimental animals depastured on his holding.

TUBERCLE-FREE HERDS.

The following herds have been declared free of Tuberculosis in accordance with the requirements of the scheme for the certifying of herds tubercle free, and unless otherwise declared the Certificate remains in force until the date shown in respect of each herd:—

Certificate No.	Owner and Address.	No. of Cattle Tested.	Date of Expiry.
1	A. Groves, Toodyay and Melville ...	226	19-1-40
2	School of Agriculture, Narrogin ...	39	17-12-39

PHALARIS TUBEROSA.

TOOWOOMBA CANARY GRASS.

H. G. Elliott,
Agrostologist.

Phalaris tuberosa is a grass which has proved one of the most hardy of our introduced species. As far as can be ascertained it was first imported into Australia by the Queensland Department of Agriculture from America as *Phalaris bulbosa* for trial at the Toowoomba Experimental Farm in 1884, hence the name Toowoomba Canary Grass. It is interesting to note that it was not until October, 1908, that the first favourable reports of this grass were published in the Agricultural Gazette of New South Wales. The following gives an abstract of some of the reports of the experimental farms as given in the article.

Hawkesbury Agricultural College.—"The leaves and stems of the *Phalaris* are soft and succulent, and the plant grows to a height of 2½ feet. It is a splendid grass for winter and spring feed and gives good growth to December when it seeds. The plants are very frost and apparently very drought resistant."

At the Wagga Experimental Farm it was reported "to be very promising as a pasture grass."

The Bathurst Experimental Farm reported that "the grass made good growth throughout the summer months, grew continuously through the winter and withstood frosting. The crowns of the plant are compact and withstand considerable trampling."

From the above reports it will be seen that this plant was considered to be a valuable asset as a pasture species.

Until about eight years ago this grass was known as *Phalaris bulbosa* or *P. commutata*. Since that time, however, botanists have agreed that the correct nomenclature is *P. tuberosa*, the name by which it is known to-day.

In Western Australia, as far as can be ascertained, it was first grown successfully by Mr. A. Snell at Harvey, and also by Sgt. W. Brodie at the Police Station at Donnybrook. Excellent growth of *Phalaris* plants can be seen on the original areas, and also along the adjoining roadways at these original sites.

Except where grown under irrigated conditions, *Phalaris tuberosa* gives early autumn, winter and spring growth, and its productiveness is practically nil during the period from early summer until the event of the first autumn rains. It is capable of adapting itself to wet cold conditions and also to extreme dryness. Generally speaking, its adaptability to extreme conditions is amazing.

In Western Australia this grass appears to be well adapted to large areas of land receiving a rainfall of 17 inches or over, which is of the winter rainfall and summer drought type. At Wongan Hills Research Station, during the last year (1938) with a rainfall of 12.76 inches its persistence was remarkable, but very little growth was obtained, this grass, however, had been growing without a legume association.

The areas of *Phalaris tuberosa* growing in Western Australia are still comparatively few and the factors that appear to have contributed towards the restricted use of this grass are:—

1. In the early introductions of seed there was present a high percentage of seeds of *P. minor*, an inferior annual species. Also the seed obtained gave a low germination, with a subsequent poor stand.
2. The grass is only a comparatively recent introduction into Western Australia.

3. The absence or comparatively poor spread of Phalaris plants on non-cultivated land by means of seed.
4. The early lack of adequate knowledge with reference to the methods of soil preparation and type, seeding and subsequent fertilizing of this grass.
5. The comparatively high price of the seed.

*Plant Description**: "Perennial, caespitose, the culms more or less swollen at the basal internodes, or forming hard woody stocks, 2-4 feet in height, erect or ascending, sometimes geniculate below. Sheaths much shorter than the upper internodes, tight and striate; ligules long, thin, white and hyaline, truncate and soon becoming lacerated. Leaf blades firm, rather soft, prominently striate, tapering into long, weak, fine points. Panicle cylindrical, spikelike, up to five and a half inches in length, compact, tapering at both ends or sometimes broader at the base, the spikelets usually erect, the peduncles ultimately long exserted.

Glumes subequal lanceolate, rather straight, more or less acute but not long pointed, 3-nerved, the lateral nerves prominent; margins wide, hyaline but firm, keeled, flat, the keel produced into a prominent dorsal wing extending over the upper two-thirds of the glume and gradually narrowed at each end, minutely serrulate or entire and not notched. Sterile lemmas not very unequal, the lower about one-quarter, the upper one-third the length of the fertile lemma, both sparsely hairy and appressed to the fertile lemma, more or less linear and concave. Fertile lemma acutely ovate-elliptical, silky with appressed hairs, faintly nerved, becoming firm in fruit; palea acute, slightly less in length than the fertile lemma, glabrous except for the terminal tuft of a few short hairs."

Seed and Strain.—Owing to the difficulty of detecting the difference between the seed of the valuable perennial type, *P. tuberosa*, and that of the inferior annual, *P. minor*, it is essential for the buyer to purchase certified seed only. The seed tester can, however, determine the difference between the two by the following processes:—

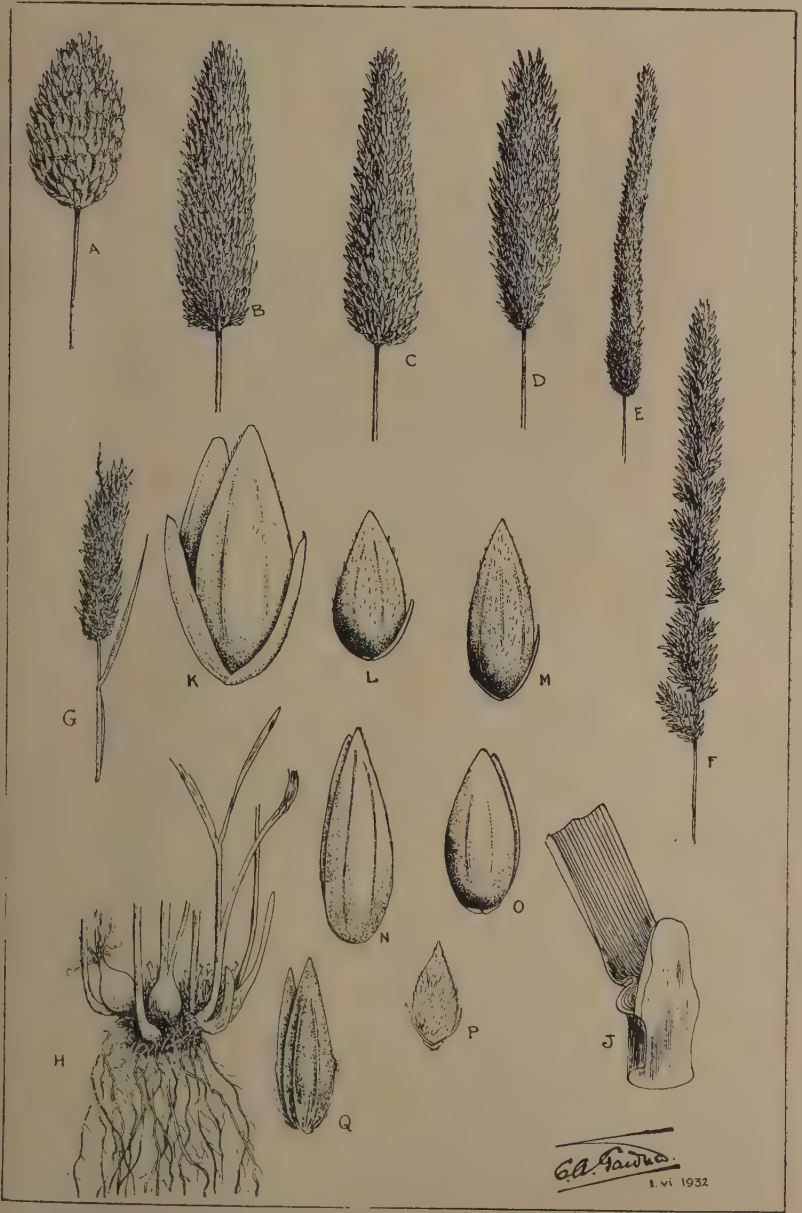
1. On the germinating filter paper *P. tuberosa* shows a white tip to the rootlets, while *P. Minor* definitely shows a pink tip.
2. Under the ultra-violet light (quartz lamp), seeds of the *P. tuberosa* when germinated on filter paper will show the roots clearly defined, while with the *P. Minor* the rootlets are not at all visible.

The Departments of Agriculture in New South Wales and South Australia have instituted a certification scheme for *Phalaris tuberosa* seed and farmers are recommended to purchase only certified seed when obtaining their requirements. Both the South Australian and New South Wales certified seed have given and are giving good results in this State.

Where to Sow.—Phalaris tuberosa is able to adapt itself to a wide range of climatic conditions in Western Australia. It is growing successfully in areas of 17 to 40 inches of winter rainfall, in summer drought conditions, and also is being grown quite successfully in our irrigation areas; it can, therefore, be realised that the value of this grass in relationship to its wide range of climatic conditions is very extensive. At the Waite Institute in South Australia, it has proved to be one of the best perennial grasses for districts where the summer months are hot and dry and the average annual rainfall is below 24 inches.

This grass appears to be best suited to the heavier soil types, but will grow well on the lighter soils which have a clay subsoil not more than 12 inches below the surface. As an association with a legume is essential, it is recommended to

* From article by C. A. Gardner and G. R. Meadley—Canary Grasses of W.A. Leaflet No. 253, Journal Department of Agriculture, W.A., Vol. IX., pp. 275-285, 1932.



EXPLANATION OF PLATE.

A.—G. Diagrams of panicles (reduced in size).

A. *Phalaris canariensis*, Linn. B. *P. minor*, Retz. C. *P. tuberosa*, Linn. D. *P. caerulescens*, Desf. E. *P. angusta*, Nees. F. *P. arundinacea*, Linn. G. *P. paradoxa*, Linn. H. Diagram illustrating the growth of *P. tuberosa*, showing the internodial swellings—the "tubers." J. Diagram of the ligule of *Phalaris*.

K.—Q. Drawings of fruits (magnified eight times).

K. *P. canariensis*. L. *P. minor*. M. *P. tuberosa*. N. *P. caerulescens*. O. *P. paradoxa*. P. *P. angusta*. Q. *P. arundinacea*.

establish it in old subterranean clover paddocks or sow the variety of subterranean clover must suitable to the district at the same time.

Soil Preparation.—In areas of 25 inches and under this is a most important factor for the future establishment and growth of this grass. It is recommended that a well prepared fallow, free of weeds and well consolidated be used. If this is available early seeding can be carried out. A firm consolidated seed bed is most essential for success. If fallowed land is not available the area to be sown should be lightly ploughed and worked down. After weed germination further cultivation will be required to destroy the weeds. After cultivation the area should be well rolled with a T-bar roller, the seed to be sown about mid-May and rolled or lightly harrowed in. Good results have been obtained by cultivating the area with a "combine" or springtyne cultivator after the weed germination has occurred. The seed is then mixed with superphosphate just prior to it being sown with the "combine" or drill set so that shallow planting is carried out. On lighter types of soil, deeper planting to 1 inch can be adopted. It is recommended, however, that a well prepared seed bed be used, as a little extra trouble in the early stages is well repaid later.

Time to Sow.—The seed may be sown from the middle of April on well worked fallow, until mid-June in the higher rainfall areas. Under irrigated conditions excellent results have been obtained from spring planting, and this is recommended when an association with white clover is required.

Rate of Seeding.—Under all conditions 2 lbs. of seed per acre is recommended and if subterranean clover seed is being sown at the same time, 4 lbs. of subterranean clover seed and 2 lbs. of *Phalaris tuberosa* seed per acre would be required. In the irrigation areas 2-3 lbs. of *Phalaris* and 2 lbs. of white clover seed per acre would be sufficient. It is not recommended to mix any seed of the ryegrasses with *Phalaris* at the time of establishment, owing to the vigorous nature of their growth in the early stages, which is detrimental to the establishment of the *Phalaris* unless excellent subsequent management with grazing is carried out. It must be remembered always that this grass is highly sensitive to competition in the early stages of growth, from any vigorous growing grass or weed, such as capeweed. Clovers such as subterranean clover and white clover can, however, be grown, and are desirable in the initial establishment of *Phalaris*.

Fertiliser.—A least 2 cwts. of superphosphate per acre should be used at the time of establishment, and a subsequent application of 1 cwt. per acre in the spring is advantageous. Two to 3 cwts. per annum should be used in the following years as a top dressing. On new land and unfallowed land that has not been under subterranean clover previously the using of 1 cwt. of sulphate of ammonia per acre at the time of planting may be beneficial.

Management.—During the first year it is essential that weeds or any vigorous growing plants should not be allowed to dominate the young *Phalaris* plants. If necessary, infrequent quick, heavy grazing, should be carried out, and any subsequent grazing should not take place at closer intervals than 6-10 weeks, according to growth. Early in October, if weeds are still troublesome, mowing should be carried out and the field closed up to allow the *Phalaris* plants to produce seed heads. Once the plants have seeded grazing can then be carried out more or less indiscriminately until the autumn rains commence, then the grazing periods should be in about 6 weekly intervals. Once established, *Phalaris tuberosa* is thoroughly perennial, increases its basal size and, grazed judicially, forms a good turf in association with clover. It is succulent and palatable to stock of all kinds. It is a strong grower, and being a deep rooting plant is reasonably drought resistant.

TANGIER PEA.*

G. K. Baron Hay, Superintendent of Dairying.

H. G. Elliott, Agrostologist.

INTRODUCTION.

The Tangier Pea (*Lathyrus tingitanus L.*) is an annual indigenous to Northern Africa, but since has been grown as an ornamental and fodder plant in Europe and America for many years.

It was first recommended and grown as fodder by Dr. Trabut, of Algeria, where it is used as a winter forage. It is cultivated also in the Canary Islands and Morocco. The first record of its introduction into the United States is given by C. R. Ball[1] in 1900, and it was not until some 20 years later that its great value as a fodder and green manuring crop was recognised.

C. V. Piper, United States Department of Agriculture, reports in 1922[2]:—

"It has given the largest yields of green matter to the acre of any annual legume grown in California. The dense growth chokes out weeds completely. It is a good green manuring crop, but the seed has been hard to get. There is hope that this difficulty may be overcome."

The Tangier pea is also cultivated as a fodder plant in the south of France, where it is said to be very hardy, and able to withstand a temperature as low as 26° F. In this connection P. de Sorney[3] reports:—

"It is a first class fodder plant and thrives very well. It is sown at the beginning of the rains and its stems rapidly cover the soil. Cattle eat it readily. Attempts should be made to acclimatise this legume in subtropical countries."

Mr. W. E. Barker,[4] Sequin, Washington, writes in 1923:—

"I grew the Tangier pea on the poorest bits of land on the farm that had been cropped to wheat for 50 years. It grew to about 7 feet high and made an impenetrable jungle."

On reading these eulogistic reports during 1925, it was thought possible that the Tangier pea would fill a useful place in agriculture in this State, and a small packet of seed, 2 ounces, was first brought into Western Australia and secured through the courtesy of Prof. P. B. Kennedy of the Agricultural Experimental Station of California. These seeds were distributed among the State Research Stations at Nabawa, Merredin, Wongan Hills and Denmark and also Mr. A. T. O'Connell, Dwarda. A careful perusal of the results obtained from a large number of trials during the years 1926-29 showed that where cultural operations had been reasonable, good results were obtained. It was noticed, however, that in almost every instance, some of the plants failed, but all failures showed similar characteristics. These features were very stunted growth, failure to develop stool and a pink to reddish discolouration of the leaves and stems. It was common to see plants only 9 inches high when six months old, while plants in the same field and planted on the same day were 7-8 feet high. This condition was found to be associated with lack of inoculation of the Tangier peas with the necessary nitrogen fixing bacteria.

The crop appears to have, at the present time, a higher commercial value for seed production than for forage use. There has been a steadily increasing market for the seed in this State, and to some extent in the Eastern States, at prices that are quite satisfactory to growers.

* Revised from the article of the same name by G. K. Baron-Hay, Superintendent of Dairying, published in this Journal, Vol. 13, No. 4, December, 1936, pp. 508-513, and which was subsequently issued as Leaflet No. 497.

DESCRIPTION.

The Tangier pea (*Lathyrus tingitanus*) is an annual leguminous plant, which in general appearance and growth resembles the ornamental sweet pea (*L. odoratum*). It is a strong grower with numerous large nodules on its roots. During the winter months, however, the plant shows slight growth only, but with the event of warmer weather in the early spring, the growth is very rapid and strong and during September it quickly attains a height from 3 to 7 feet in a tangled mass, producing a dense covering which chokes out all but the strongest weeds.

The plant is smooth throughout with coarse stems and prominent stipules. The leaves consist of a pair of large leaflets and a large branched tendril terminating the mid-rib of the leaf. From the axils arise stalks which bear two to three flower clusters of bright scarlet flowers, which are about the size of small sweet pea blossoms. The pods are about 3 in. long, containing five to seven seeds. The seeds are brown, eliptical, somewhat flattened and about ¼ in. long. The hilum or scar is whitish, and ⅛ in. long. This pea is drought resistant to a high degree, this being due to a deep rooting habit.

RELATED SPECIES.

The genus *Lathyrus* is represented by about 100 species, growing generally in the Northern Hemisphere and a few in the mountains of tropical Africa and some in South America. Two species which have given some promise in this State are (1) the grass pea (*L. sativus*), also known as the Swiss pea. This is a much earlier species than the Tangier pea and is in full flower by the middle of October. The yield of green material and seed is good, but not equal to the Tangier pea; and (2) *L. annus*. This species has a much finer type of stem and smaller leaves than the Tangier. Rapid growth does not commence until early September, and flowering begins early in November. This species is a very heavy yielder of seed, and produces a good bulk of green material.

The comparisons of these *Lathyrus* species were made by growing them at the Denmark Research Station.

WHERE TO SOW.

In Western Australia the Tangier peas have, generally, succeeded best on well drained loams and sandy loams of reasonable fertility. Good drainage is one of the most necessary requirements for successful production. Where they are sown on poorly drained country very little growth is obtained and a red discolouration of the leaves takes place. It has, however, been grown successfully on most of our 18 in. and over rainfall areas.

TIME OF SOWING.

Usually the best time to sow the Tangier pea is immediately after the event of the general winter rain. As they have rather a long growing period, it is necessary to sow them before June, so that plant maturing will take place before the soil dries out in the late spring.

PREPARATION OF THE SEED BED.

Observations have shown that in many cases the success of a crop has been in proportion to the method, in which the seed bed has been prepared. The land can be skim ploughed and cultivated similarly to that for the sowing of a cereal crop such as oats. The seed can be either broadcasted and harrowed in, or sown from a drill or combine.

RATE AND METHOD OF SEEDING.

To obtain a heavy crop during the first season, it is recommended that up to 30 lbs. of seed per acre be planted, with 1 to 1½ cwts. of superphosphate. Good results can be obtained, however, in the second year, by planting 8 to 10 lbs. of seed per acre with a similar quantity of superphosphate. For hay and silage, crops, Tangier peas can be grown in association with oats, the rate of seeding being 5 to 8 lbs. of Tangier peas with 1 bushel of oats, and an application of 1½ cwt. of superphosphate. For green manuring purposes, the seeding rate depends very largely upon the amount of material desired for turning in, and upon the cost of the seed. Seed rates as high as 40 lbs. per acre may be required. The seed can be sown through a drill or combine to a depth of 1 in. to 1½ in. Light harrows should follow after the drill or combine. When sown broadcast, however, it is necessary to use good spike harrows for incorporating the seed into the ground.

INOCULATION.

The Tangier pea, being a legume, requires inoculation for the best crop production, and it cannot thrive without the assistance of nitrogenous fertilisers unless the necessary nitrogen fixing bacteria are found in association with it, and growing

TANGIER PEAS.

Demonstration showing the effects of want of inoculation. Ladies standing on the uninoculated patch. Hat can be seen on gentleman standing in peas to the left of photo.

in colonies or nodules on its roots. The nodules produced on the roots of vigorous healthy Tangier peas are large and numerous. The absence of the nitrogen fixing organisms has been responsible for a number of failures in the initial establishment of the Tangier pea in Western Australia. The inoculation of the seed may be done with cultures as prepared by the Department of Agriculture, and it is advisable, after inoculating the seed, that the inoculated seed should not be exposed to direct sunlight. The seed should be inoculated just prior to seeding. The cost of inoculation is so small that no seeding should be carried out on land which has not grown Tangier or field peas previously, unless they are inoculated. This often means the

difference between the success and failure of the crop. Seed which has been inoculated should not be mixed with superphosphate prior to planting, as the superphosphate injures the bacteria. The best practical methods of sowing are those in which the inoculated seed is sown at the same time as the superphosphate, when the contact between the seed and fertiliser is only momentary, as in the case when sowing with a combine or drill. It must be remembered, however, that the ground should be wet at the time of seeding under these conditions.

USES OF THE TANGIER PEA.

The Tangier pea can be used for all types of forage, such as hay, silage, and as a green manuring crop.

1. *As a Forage Plant.*—As some guide to the feeding value of the Tangier pea, samples of the plant were submitted to the Government Analyst (Dr. E. S. Simpson) for analysis.

The following table shows the Tangier Pea compared with White Dutch Clover and the Common Vetch:—

	Water.	Ash.	Crude Protein.	Carbohydrates.		Fat.
				Fibre.	Nitrogen Free Extract.	
White Dutch Clover	8·1	8·0	16·2	23·2	41·6	2·9
Vetches (common)	7·1	8·2	17·3	26·2	38·7	2·8
Tangier Pea	6·36	6·12	17·94	25·12	40·62	3·84

It will be seen that the Tangier Pea closely approximates to the values of these two legumes, as revealed by chemical analysis.

Mr. O'Connell reports that the pea is relished by all stock, which smashed a fence against which the plants were growing in order to reach them.

The leafage and stalks are eaten by stock, and, in Algeria and California, where considerable quantities have been fed to stock, no deleterious effects have been recorded.

TANGIER PEA STRAW.

	Moisture.	Ash.	Crude Protein.	Carbohydrates.		Fat.
				Fibre.	Nitrogen Free Extract.	
1. Bean Straw	11·07	6·97	5·68	41·10	33·63	1·52
2. Oaten Hay	8·6	4·7	3·80	31·0	49·2	2·6
3. Oaten Straw (Stubble) ...	11·5	5·4	3·60	36·3	40·8	2·4
4. Tangier Pea Straw ...	10·0	10·64	6·42	37·10	34·06	1·78

1. Hendry, G. E.: Bean Culture in California. Bulletin 294. California Agricultural Experiment Station.
2. West Australian figures.
3. Henry and Morrison: Feeds and Feeding.
4. P. B. Kennedy: The Tangier Pea. Circular 290. University of California.

VALUE OF STRAW.

Mr. O'Connell has found that all stock—sheep, horses and cattle—eat the pea straw with relish, cattle in particular being very keen on it.

While it is not advisable that the straw should be considered suitable as a feed for stock by itself, there is no doubt that the straw, when chaffed, would make a valuable bulk feed, especially for cattle.

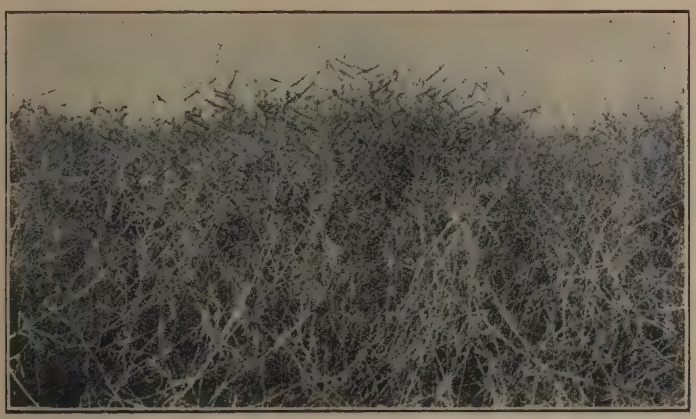
The above comparisons of Tangier pea straw with bean straw, oaten hay (local), and the oaten stubble indicates that the Tangier pea straw has a decided feeding value and compares more than favourably with oaten stubble.

For feeding to cattle it is advisable to chaff the straw and moisten it some hours before feeding.

3.—A SEED CROP.

One of the principal difficulties with the Tangier pea is to obtain the seed cheaply, although they have given excellent results in this State. Commercial quantities of the seed are now available in limited quantities, this being brought about largely through the efforts of Mr. O'Connell of Dwarda. The best method of harvesting the seed is as follows:—

The tangled growth is generally so large and dense that it is rather difficult to cut the material in such a manner as to make it readily available for the threshing machine. Methods used have been to cut the material at the base near the



A crop ready to harvest. The straw is fine and relished by stock.

ground with a mower, and to roll the cut plants out of the way for the next cut. It is then bunched together and carted to a convenient spot for threshing. This operation should be carried out before the plants have reached full maturity, to reduce as much as possible the shedding of the seed. Very little trouble is encountered in separating the seed from the pods and straw by any ordinary threshing machine, and as there would be no weeds present, it is usual to obtain a good quality of seed that needs very little or no additional cleaning. An average of approximately 1 ton of seed can be obtained per acre. The seed weighs 60 lbs. per bushel.

SUMMARY.

1. The Tangier pea is an excellent fodder plant and useful for green manuring in districts with an 18in. winter rainfall and over.

2. Early planting (May) is recommended. As the plants grow but little during the cold winter months, this early planting is important.

3. The plants require six to seven months to reach maturity.

4. Grown with oats, produces an excellent crop for hay and silage.

5. Inoculation of seed is essential for success.

6. At least 1 to 1½ cwts. of superphosphate per acre should be applied.

8. Related species *Lathyrus annus* and *L. sativus* are showing that they can be of value as forage plants.

7. Well drained land is essential for the successful growth of Tangier peas.

References:

1. Ball, C. R.—"Grasses and Fodder Plants on the Potomac Flats," U.S. Dept. Agr., Div. Agrost., circ. 28 : 14, 1900.
2. Piper, C. V. and Pieters, A. J.—"Green manuring," U.S. Dept. Agr., Farmers' Bull. 1250 : 42, 1922.
3. P. de Sorney—"Green Manures and Manuring in the Tropics," 1916.
4. P. B. Kennedy—"The Tangier Pea," Univ. of California, circ. 290, 1925.

PASTURE DEVELOPMENT.

By H. G. ELLIOTT, Agrostologist.

The four year's report on the rotational grazing demonstration under irrigated conditions being conducted on the property farmed by Mr. D. Moore and owned by Mr. A. E. Jackson, of Roelands, is now available. This demonstration, along with those on the properties of Messrs. J. Neil and C. H. Henning, of Waroona and Hamel respectively, have been conducted as a co-operative project by the State Committee of the Australian Dairy Council and the field staff of the Department of Agriculture.*

The objects of the demonstration include:—

1. The collection of data regarding the carrying capacity of small areas.
2. The collection of information as to whether it would be more profitable to establish a permanent pasture with a cover crop than to sow the perrenial pasture species alone.
3. To obtain the monthly yield of green material per acre
4. The collection of data to show the change in botanical composition due to rotational grazing under irrigated conditions.
5. To test the effect of varying the time between waterings during the irrigation season.

Full particulars with reference to soil type, seed mixtures, fertilisers, cultivation, irrigation and cover crop for each field have been given in detail in previous reports. The following details give further results of the experiment for the year ending the 31st December, 1938.

Fertiliser.—The rate of application for the fertilisers for the fourth year, 1938, was slightly lower than that of the third year, being 5 cwt. per acre, applied in three applications, the main application being given in the autumn.

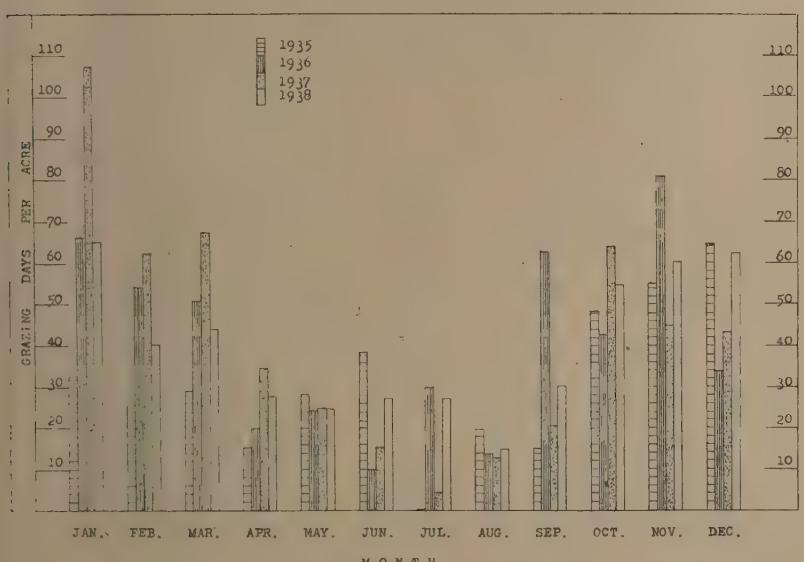
* A resume of the first three years' operations has been published in the March, 1936, 1937, and 1938 issues of this Journal.

The quantity of fertiliser applied during 1935 consisted of 904 lbs. of superphosphate and 218 lbs. of sulphate of ammonia per acre. In 1936, 374 lbs. of superphosphate and 28 lbs. of sulphate of ammonia were applied. In 1937, 600 lbs. of superphosphate were applied. It will be noticed that no sulphate of ammonia has been applied during the past two years. Early in 1936, half of each field was limed with agricultural lime, at the rate of 4 cwts. per acre. To date no effects from this application have been noticed.

Renovation.—During the middle of July, 1938, all plots received a severe surface renovation with the rotary type of renovator known as the "Sunprong." Following the double renovation which was carried out, a pasture blade type of harrows was used. All furrows were cleaned out, with a modified type of "Sunbuster" plough, this to facilitate watering during the summer months. The complete area was topped with a mower during the summer to assist in preventing seed production of the paspalum.

Irrigation.—Owing to the system of irrigation being altered to enable the Irrigation Officers to carry out a time of watering experiment no details of watering can be given. Mr. L. C. Lightfoot, Agricultural Adviser of the Irrigation Branch, has appended the details of the methods being adopted.

GRAPH 1. AVERAGE MONTHLY GRAZING DAYS (8 HOURS) PER ACRE



Above Graph No. 1 shows the monthly production in grazing days per acre for the four years. It will be seen from this graph that the average monthly grazing was 40 grazing days per acre, which is slightly lower than that of the previous two years, *i.e.*, 1937, 42.2, and 1936, 41.3. The months in which the principal reduction in grazing took place were those of January to April inclusive and October. This lighter grazing during the summer months gave rise to an increased grazing during the months of June and July. It will be seen, however, that the production for the month of August was approximately the same. The total grazing obtained from all fields averaged 480.5 grazing days per acre per annum. This is very close to the grazing figures obtained during the previous two years.

No reason can yet be given for the rapid decline in production which occurs each year during the month of February. In three years, this decline was followed by a slight increase in production for the month of March. The heavy decrease in grazing occurs during April and continues during the winter months, until the spring flush occurs in September. The winter months June to August are definitely the light production period of the year.

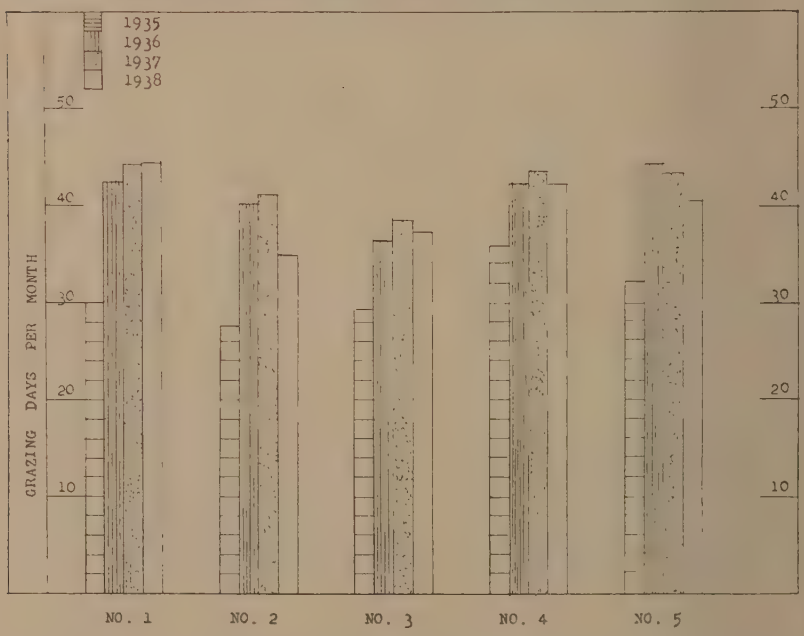
Table 1 gives the full grazing production for the years 1935 to 1938 inclusive.

TABLE 1.

Year.	Grazing hours.	Total grazing days.	Grazing days per acre.	Acres per cow.
1935	38,373	4796·6	371·2	0·97
1936	47,019	5877·4	496·1	0·73
1937	52,200	6525·0	506·6	0·72
1938	49,430	6178·7	480·5	0·76

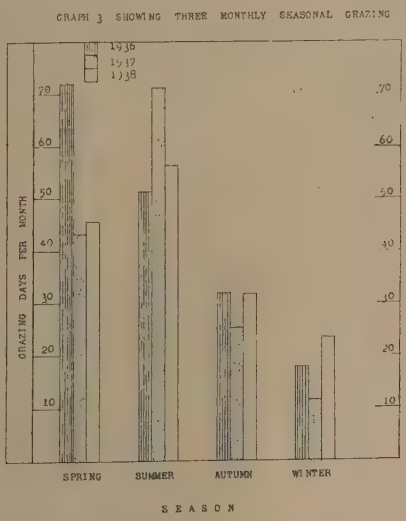
From the above table it will be noted that the complete area has maintained a high carrying capacity, and that during the past three years it has been constant, being equivalent to approximately one cow to ¾ acre.

GRAPH 2. GRAZING DAYS 8 HOURS PER ACRE

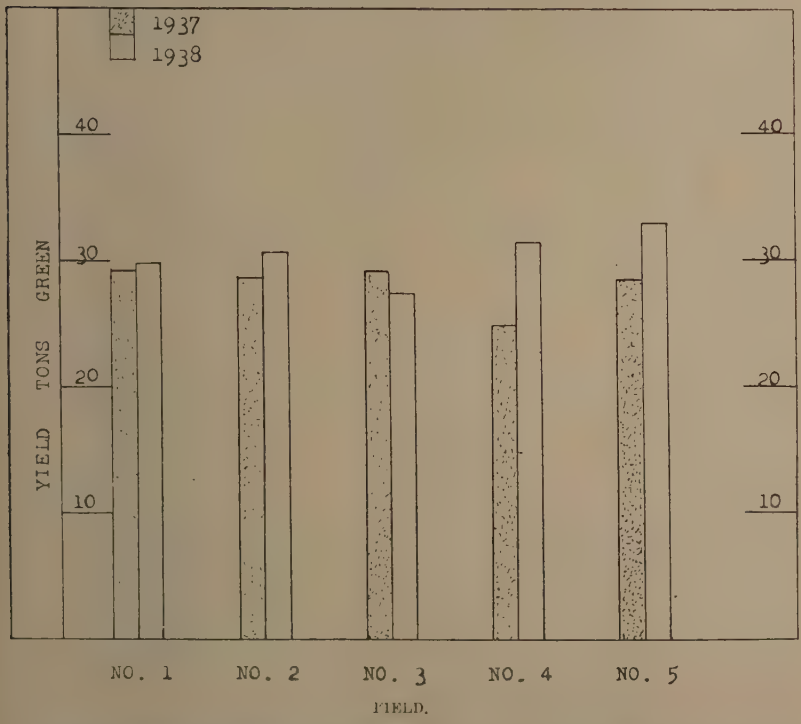


Graph 2 above shows the grazing days per acre obtained for the individual fields for the years 1935 to 1938. The most marked annual variation occurs in Field No. 3. This field initially had the heaviest cover crop, *i.e.*, Japanese Millet. This cover crop affected the constant and rapid spread of White Clover, and allowed Couch Grass to dominate in sections. It is quite obvious that no beneficial effects were obtained in establishing a permanent pasture under irrigated conditions with a heavy cover crop. Even the additional yield of the cover crop did not bring about the highest production in grazing for the first year.

Graph 3 shows the monthly variation in grazing days which occurs during the three month seasonal periods of the year. From this graph it will be noted that the spring and summer production is high, and that the summer production during the past two seasons has exceeded the spring production. It will be seen, however, that a rapid decline takes place in the autumn, and that the winter production is very low. The 1938 winter production indicates a decided improvement on the previous two years' figures. A similar rise and fall in tons of green material per acre can be noted in Graph 5.

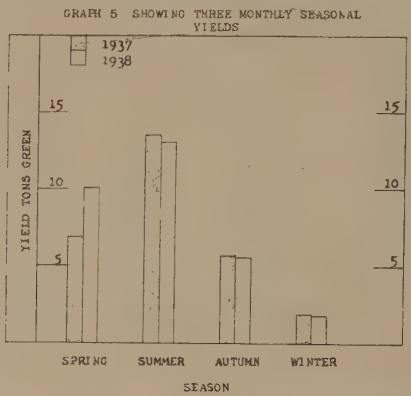


GRAPH 4 ANNUAL PRODUCTION IN TONS FOR THE FIVE FIELDS



Graph 4 gives the annual production in tons of green material for the five fields for the years 1937 and 1938. It will be noticed that very little variation

occurred in the production of the fields during the two years except in the case of Field 4, where a decided increase occurred. During the period 1937, the average production of the whole area was 28.1 tons per acre, whereas for the year 1938 the production of green material was 30.5 tons per acre.



The above graph gives the three monthly seasonal yields in tons of green material per acre for the two years 1937 and 1938. It will be seen from this graph that the main production occurs during the summer months December to February. Actually 42.6 per cent. of the production occurred in these months for the year 1938 as compared with 48.6 per cent for 1937. The spring production for 1938 has shown a decided increase, being 33 per cent. of the total production. It will be seen, therefore, that for the period September to February inclusive, 75.6 per cent. of the production was obtained . There was practically no alteration in the winter and autumn production for the two years, the winter production for 1938 being 6 per cent. of the total as against 7 per cent. for 1937. This shows that these three months are undoubtedly the ones where the least amount of grazing can be expected, and it is necessary for the farmers to have ample conservation for these months and also for the autumn period.

Tentative Conclusions.—The results indicate that:—

1. Rapid growing cover crops are detrimental to the initial establishment of white clover, and to a much less degree *Paspalum.* If couch grass (*Cynodion dactylon*) is present at the time of seeding, heavy cover crops will definitely assist the spread of it to the detriment of sown pastures, more particularly where these pastures are sown in the spring months.

2. Rapid growing cover crops are not recommended when establishing permanent pastures under irrigation.

3. Rates of superphosphate up to 6 cwt. per acre are considered profitable, and at least 4 to 5 cwts. should be applied annually in two or three applications, the heavier rates per acre being applied in the autumn. Indications show that summer applications of superphosphate just prior to irrigation are profitable.

4. Superphosphate and ammonia mixtures can only be recommended as an initial application at the time of planting. A minimum of 2 cwt. per acre should be applied.

5. The following seed mixtures can be recommended for irrigation areas:—
   (a) New areas where no irrigated pasture existed previously: *Paspalum dilatatum*—8 lbs. per acre; New Zealand Certified white clover—2 lbs. per acre.

(b) Where some irrigated pastures already exist: Certified perennial ryegrass—4 lbs per acre; *Paspalum dilatatum*—6 lbs. per acre; New Zealand Certified white clover—2 lbs. per acre; or

Certified perennial ryegrass—6 lbs. to 8 lbs. per acre; Certified Akaroa Cocksfoot—2 lbs. per acre; Certified white clover—2 lbs. per acre; or

Phalaris tuberosa—2 lbs. to 3 lbs. per acre; Certified white clover—2 lbs. per acre.

APPENDIX.

The irrigation schemes in this State have been designed for a monthly interval between waterings. With the introduction of better class pastures there is ample evidence to show that this interval is too long, especially during the height of the summer months.

The Irrigation Branch has designed, therefore, an experiment, the object of which is to obtain reliable data with reference to the frequency of irrigation required by permanent pastures.

For the purposes of this work a water requirement of $1\frac{1}{3}$ inches per week has been adopted tentatively. On this basis, Field No. 3 is watered at intervals of two weeks, Fields Nos. 2 and 4 at intervals of three weeks, and Fields Nos. 1 and 5 at intervals of four weeks, receiving respectively $2\frac{2}{3}$ inches, 4 inches, and $5\frac{1}{3}$ inches of water per irrigation, the water being measured by means of a series of gauges installed for this purpose.

By courtesy of the Australian Dairy Produce Board Pasture Improvement Committee (W.A.), Mr. D. W. Moore and the Dairy Branch, the experiment is located on the Council's irrigated permanent pasture paddocks, controlled for pasture experiments by the Dairy Branch and situated on the property of Mr. A. Jackson, of Roelands, which is farmed by Mr. Moore.

The co-operation of the Dairy Branch and the Agrostologist enables the effect of the various irrigation treatments on the productivity, condition and technical composition of the pastures to be measured.

It is considered that, owing to the short time the experiment has been under way, no attempt as yet can be made with reference to the drawing of any conclusions.

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EGG-LAYING TRIALS.

MURESK AGRICULTURAL COLLEGE.

G. D. SHAW, Poultry Adviser.

The 1938-39 trial is the third of the second series conducted at Muresk Agricultural College. Seven previous trials were held prior to 1936, but a break occurred in the years 1933-35.

The duration of the trial is 48 weeks, beginning on 1st April, 1938, and ending on 2nd March, 1939.

For the present 1939-40 trial the birds were penned on 16th March, and will continue until the 1st February, 1940, and the 1940-41 trial will commence on 1st March, 1940, and continue for 48 weeks ending 29th January, 1941.

The earlier starting is considered advisable because of the local seasonal conditions. It is recognised that in Western Australia, August is the correct month for hatching and therefore the trials should commence within reasonable time 6 to 6½ months later. In the past it has been noticed that many birds had been laying before they arrived at the College and in many cases these ceased laying and then moulted. The holding of the commencement of the trial meant that the birds were in some cases eight months old, or should they be younger, then they had been late hatched, neither condition being advantageous to the stock. In order to advance the date of commencement without disorganisation, it was considered advisable to have two forward movements of 16 days rather than one of 31 days.

Breeders entered 294 birds for the 1938-39 trial. (All birds are weighed at the beginning of the trial and during the progress of the season they are check weighed for condition.)

MANAGEMENT.

The management of the Trial is in the hands of a committee which consists of the Principal of the College (Mr. W. Southern) (Chairman), the Poultry Adviser of the Department of Agriculture, Mr. G. D. Shaw, the Assistant Poultry Adviser, Mr. E. Lovegrove, Mr. S. Dolman, Cranleigh Poultry Farm, Mr. F. Landquist, York, and Mr. R. Knight, Kenwick, the three latter gentlemen being the representatives of the competitors. The Committee of Management meet at the College once a month and direct the policy of the trial.

There are 360 pens available and all birds are tested individually, all eggs being weighed daily and the scales used are tested and graduated to one-tenth of an ounce. The College is situated some 60 miles from Perth. The soil is ideal and the conditions good. Heat in summer has at times caused distress, but this factor is now held in check by the growth of lilacs which are in between the rows of the laying pens. The pens are in rows of 84 with a break in the centre of the row.

The conditions governing the 1938-39 trial were as follows:—

COMMITTEE OF MANAGEMENT.

The Committee of Management shall consist of the Principal of the College, the Poultry Adviser, Department of Agriculture, the Assistant Poultry Adviser, or officers acting in their stead, and three representatives elected from the breeders taking part in the preceding trial.

Note: The term "breeder" is given to those who have entered birds in the trials.

POWERS OF THE COMMITTEE.

The Committee shall have absolute control of the trials conducted during its tenure of office.

It shall recommend what tests are to be carried out and arrange the conditions and regulations governing the same.

The representatives elected shall take office on 1st April succeeding the date of appointment.

The Committee shall meet at such times as it may deem necessary.

The trial shall consist of the following sections:—

Section "A."—Pen of Six Birds—All Light Breeds.
Section "B."—Pen of Six Birds—All Heavy Breeds.
Section "C."—Pen of Six Birds—All Medium Heavy Breeds.

The trial shall extend from 1st April until 2nd March (48 weeks). The leading group or individual bird in each section may be allowed to remain at the College for the full period of twelve months.

Each breeder shall be charged an entrance fee of 5s. per bird, 2s. 6d. per bird to accompany application for pens. The balance of 2s. 6d. per bird is to be forwarded to the Principal, Muresk Agricultural College, within 14 days after notice of allotment of pens; otherwise pens may be allotted to other applicants and the 2s. 6d. application fee forfeited.

For any of the above sections pure-bred birds only must be entered.

All eggs shall be the property of the Muresk Agricultural College.

Each of the pullets will be single tested, housed (semi-intensive), and the individual numbers and weight of eggs will be kept.

REGULATIONS.

(1) In each section the trial will be decided by the highest number of first-grade eggs obtained by each group of birds and by each individual bird in their respective sections.

(2) Sections "A," "B," and "C."—During the first two months of the trial a first-grade egg shall weigh not less than $1\frac{3}{4}$ ozs., thereafter during the remainder of the trial a first-grade egg shall weigh not less than 2 ozs.

Second Grade.—The minimum weight of a second-grade egg shall be not more than $\frac{1}{4}$ oz. less than a first-grade egg. Second-grade eggs will be recorded but not counted.

(3) Eggs under $1\frac{1}{2}$ ozs. in weight during the first two months of the trial and under $1\frac{3}{4}$ ozs. in weight during the remainder of the trial, soft-shelled, or broken will be recorded, but not counted in trial results.

(4) In all sections the actual weight of each egg shall be kept.

Note: The certificate for the winter test, 1st April to 31st July, shall be given subject to Rules 2 and 3.

(5) Progress results will be published weekly as far as practicable, and all prizes shall be awarded as soon as possible after the termination of the trial. Results to be reported under breed headings.

(6) No protest shall be considered unless received within 14 days of the alleged breach of regulations, and accompanied by a deposit of £1, which deposit shall be returned if the protest is upheld, or forfeited if, after inquiry, the protest is considered to be frivolous or without foundation.

(7) Records shall be kept of the average cost per head of food consumed.

(8) All birds to be accepted must conform to the following conditions:—

(a) Shall be the property of the breeder.

(b) Must be not less than six months and not more than nine months of age on 1st April.

(c) Must be fair specimens of the breed.

(d) Must weigh not less than—

	lbs.
Section "A"—Light Breeds—	
Leghorn, Ancona	3¾
Minorca	4
Section "B"—Heavy Breeds—	
Australorp	5
Sussex, Langshan	5
Plymouth Rock	5
Section "C"—Medium Heavy Breeds—	
Barnevelder	5
Rhode Island Red	5
Wellsummer	4½
Wyandotte	4½

(9) All birds sent to the trial must conform with the weight prescribed in the preceding paragraph, otherwise the committee shall cancel the allotment pens, in addition to which the entrance fee may be forfeited.

(10) All birds shall be treated for vermin and delivered at the Muresk Agricultural College, Muresk, between 27th March and 31st March, inclusive, in new coops or crates, with the breeder's name and address clearly stencilled or painted thereon. Entries will not be accepted from any person whose premises are tick-infested or whose flock is suffering from any infectious or contagious disease.

(11) Freight to the College is to be prepaid or delivery will not be accepted. Freight on rejected birds must be paid by the breeder.

(12) All birds must be ringed with the numbered leg bands supplied and forwarded free to the breeder. These will correspond with the number of the pens allotted.

The pens having overhead netting, it is unnecessary to cut any bird's wing feathers.

(13) The Poultry Adviser, or his representative, shall have the power to reject any bird which, in his opinion, is not of the correct age, or which he considers does not conform in any way to rule 9, and his decision shall be final.

(14) Any bird found to be suffering from an infectious or contagious disease, or with crooked breasts, or side springs in combs will be rejected and returned, and shall be replaced by a suitable one within seven days after the notification of same. If any bird is found infested with tick the group will be rejected, the entry cancelled, and the entry fee forfeited.

(15) In the event of a bird during the course of the trial becoming diseased, incapacitated from laying, or developing vicious habits (such as egg-eating or feather-eating) it may be returned, or, on the written authority of the owner, destroyed.

Should this occur, the breeder may replace it with another bird of the same age and breed; in the case of a bird dying, replacement may be made. Any score standing to the credit of a bird which is replaced shall be struck out.

(16) No breeder shall withdraw any bird until the termination of the trial, except as provided in rule 15.

(17) The committee reserves to itself the right to inspect or to have inspected any applicant's stock with a view to determining whether the quality and character of the birds warrant the allotment of pens.

(18) (a) Any breeder taking part in the current trial will have the right of allotment of one pen of six birds per section in the succeeding trial. After such allotment new applications will have the right of allotment of one pen of six birds per section. Should there then be any vacant pens they will be allotted by ballot to any applicant.

(b) If after the allotment of pens it is ascertained that incorrect information has been furnished the allotment may be cancelled and the birds returned. In such case the entrance fee shall be forfeited and the applicant may be debarred from entry to any future trial.

(19) Any breeder violating or failing to conform to these regulations shall be subject to such disqualification as the committee may decide.

(20) Where there is a tie for any place, the award shall be given to the breeder whose bird or group (as the case may be) lays the greater total weight of first-grade eggs.

(21) While every care will be taken, the committee will not be responsible for loss or injury to any birds in any way in connection with the trial.

(22) The committee may disqualify any breeder and may refuse entry to subsequent trials where such breeder published in any way statements of records not in accordance with the official records of the trials.

(23) The committee's decision in all matters shall be final.

PRIZES.

Note:

Certificates will accompany all prizes.

No prizes shall be awarded in any section unless there are at least four entries.

CHAMPION CERTIFICATE.

A champion certificate will be awarded to the group pen from sections "A," "B," and "C" obtaining the highest total of first-grade eggs during the term of the trial.

GOVERNMENT STANDARD CERTIFICATE.

A Government standard certificate and a registered sealed copper ring will be awarded to all birds laying not less than 200 first-grade eggs or over during the term of the trial.

DISCUSSION.

Some explanation with reference to the classes may not be out of place. In the schedule it will be noticed that light, heavy, and medium-heavy classes are defined by weight. This is not a clear interpretation of the classes. It has been found that the activity of the different breeds varies, so much so that the feeding of light birds must be on a different plane to the feed given to the heavy. It was found that the food giving the best results for light breeds was too fattening for the heavy breeds. This was because the heavy breeds were not as active as the light and therefore did not utilise the carbohydrates to the best advantage. Hence the heavy breeds are fed on a narrower ration than are the light breeds.

Again, the breeds placed into what is described as medium-heavy, are not necessarily lighter in weight than are the heavy breeds, but those placed in the medium-heavy class are more active than those breeds placed in the heavy class, yet not as active as those of the light breeds quoted. Hence the rations suitable for the

medium-heavy breeds should be wider than that given for the heavy breeds but narrower than that given to the light breeds. This has been satisfactory and the feeding at the laying trial is based on the article on "Feeding" published in the Journal of Agriculture, September, 1934, pages 435 onwards, and in the December, 1936, Journal, pages 465 onwards. This system of feeding allows the birds the necessary requirements of protein and carbohydrates consistent with their activities, and the noticeable factor at the completion of each trial of the second series has been that the birds have been returned to their owners in good condition, each bird having put on weight during the period, but no bird has carried superfluous fat.

Australorps again proved their superiority over the White Leghorns. There is no need for alarm at such a result, but the breeders are alive to the shortcomings and the trial for 1939-40 should show a marked improvement in production.

The following are the results of the trial ending 2nd March, 1939:—

SUMMARY.

	Score.
Section A. Team of 6 Birds—Light Breed.	
1st (Westfarmers' Cup), Mrs. E. E. Price—	
1st Grade Eggs	1,261
2nd Grade Eggs	6
2nd (Wright & Co. Trophy), Robinson Bros. (1)—	
1st Grade Eggs	1,186
2nd Grade Eggs	6
Section B. Team of 6 Birds—Heavy Breed.	
1st (W.A. Prod. Market Cup), Wyndella Poultry Farm—	
1st Grade Eggs	1,275
2nd Grade Eggs	87
2nd (R. Piercey Trophy), A. R. Caporn—	
1st Grade Eggs	1,254
2nd Grade Eggs	187
Section C. Team of 6 Birds—Medium-Heavy Breed—	
1st (Ian Hazlett Cup), F. Landquist & Son—	
1st Grade Eggs	964
2nd Grade Eggs	103
2nd (Kirkby Trophy), Cranleigh Poultry Farm—	
1st Grade Eggs	917
2nd Grade Eggs	113
Section A. Highest Single—Light Breed.	
1st (Macfarlane Cup), Runnymede Poultry Farm, Bird No. 6—	
1st Grade Eggs	241
2nd Grade Eggs	..
2nd (Jas. Goss Trophy), Mrs. E. E. Price, Bird No. 74—	
1st Grade Eggs	240
2nd Grade Eggs	1
Section B. Highest Single—Heavy Breed.	
1st (Bairds Co. Cup), M. H. Dadley, Bird No. 67—	
1st Grade Eggs	283
2nd Grade Eggs	..
2nd (Barrow Linton Trophy), Thorpe Poultry Farm, Bird No. 127—	
1st Grade Eggs	274
2nd Grade Eggs	6

Section C. Highest Single—Medium-Heavy Breed.

1st (Enston Cup), F. Landquist & Son, Bird No. 141—
1st Grade Eggs 210
2nd Grade Eggs 3

2nd (Harrold & Murray Trophy), Cranleigh Poultry Farm, Bird No. 134—
1st Grade Eggs 206
2nd Grade Eggs 1

First bird to lay 200 First Grade Eggs—

Light (J. & W. Bateman & Co. Trophy), Mrs. E. E. Price, Bird No. 74—2nd January, 1939.

Heavy (T. Newby & Co. Trophy), M. H. Dadley, Bird No. 67, 14th November, 1938.

Medium-Heavy (Spearwood Poultry Farmers' Cup), F. Landquist & Sons —No. 141—15th February, 1939.

Winter Test (1st April to 31st July).

(Trophies donated by Philip Giles, Manager of Nelson & Co., Metropolitan Markets, Perth).

	Score.
Team of 6 Birds—Light Breeds, 1st only, E. Singleton—	
1st Grade Eggs	400
2nd Grade Eggs	1
Team of 6 Birds—Heavy Breeds, 1st only, M. Wall—	
1st Grade Eggs	496
2nd Grade Eggs	48
Team of 6 Birds—Medium-Heavy Breeds, 1st only, R. Harrison—	
1st Grade Eggs	398
2nd Grade Eggs	21

Summer Test—Team laying greatest number of First Grade eggs in the period 1st December-2nd March inclusive. (Teams to have laid 1,200 First Grade eggs in the period of the test.) Cups donated by the Western Ice Co.

Section A. Team of 6 Birds—Light Breeds. Mrs. E. E. Price—353 1st Grade.

Section B. Team of 6 Birds—Heavy Breeds. *Thorpe Poultry Farm—275 1st Grade.

Section C. Team of 6 Birds—Medium-Heavy Breeds. No team laid 1,200 1st Grade eggs.

Special Prizes.

Robinson Trophy—Team laying lowest percentage of second grade eggs (minimum total lay of 1,000 First Grade eggs)—

M. H. Dadley—1,133 First Grade, 2 Second Grade.

A. S. Webb, Kirup, Trophy—Bird laying longest sequence of First Grade eggs after 1st June to conclusion of test—

Mrs. E. Kerr—Bird No. 4 (sequence of 97 two-ounce eggs). This bird laid a total sequence of 167 recorded eggs.

Champion Certificate—Wyndella Poultry Farm—Australorp. 1st grade eggs 1,275; 2nd grade 87.

* Under regulation No. 21, total weight of First Grade eggs showed:—
Thorpe Poultry Farm—618 ozs.
Wyndella Poultry Farm—602.1 ozs.

DETAILED RESULTS.

SECTION "A" (LIGHT BREEDS)—TEAMS OF SIX BIRDS.

Name of Competitor and Birds Nos.	1st.	2nd.	1st.	2nd.	1st.	2nd.	1st.	2nd.	1st.	2nd.	1st.	2nd.	Totals. 1st.	Totals. 2nd.
Runnymede Poultry Farm (1–6) ...	148	96	187	3	218	6	153	2	229	3	242	...	1,176	110
Cranleigh Poultry Farm (7–12) ...	216	...	200	1	125	15	194	4	67	134	214	8	1,016	162
Webb's Hatchery (13–18)	225	...	165	2	141	16	136	4	222	5	116	3	1,005	30
E. Singleton (19–24)	166	10	209	3	205	13	163	69	148	12	201	...	1,092	107
R. Lowe (25–30)	194	8	65	...	165	1	196	2	48	30	110	74	778	115
Mrs. R. Lowe (31–36)	133	34	190	9	196	3	141	9	165	12	125	36	950	103
Thorpe Poultry Farm (37–42) ...	160	14	136	52	152	10	142	44	198	4	116	11	904	135
M. H. Dadley (43–48)	161	20	204	...	176	5	146	4	195	3	178	1	1,060	33
Mrs. M. H. Dadley (49–54) ...	89	7	150	1	...	...	133	13	150	90	196	19	718	130
F. B. Vickers (55–60)	130	7	37	13	77	2	192	23	158	...	169	3	763	48
R. Harrison (61–66)	162	1	179	12	209	15	221	2	153	...	46	...	970	30
E. E. Price (67–72)	153	3	163	1	161	...	186	2	187	...	194	...	1,044	6
Mrs. E. E. Price (73–78)	227	...	240	1	235	...	189	2	183	...	187	3	1,261	6
H. P. Chalmer (79–84)	172	31	69	78	236	2	193	6	198	11	66	9	934	137
Robinson Bros. (1) (85–90) ...	199	...	155	1	169	4	227	...	206	...	230	1	1,186	6
Robinson Bros. (2) (91–96) ...	202	3	204	2	221	...	172	1	147	...	194	...	1,140	6
T. Gent (97–102)	189	6	203	8	40	43	94	124	128	67	139	29	793	277
H. Jager (103–108)	172	...	196	8	227	...	186	...	142	7	163	63	1,086	78
W. G. Hall (109–114)	188	6	134	57	161	12	164	45	153	65	147	61	947	246
R. Knight (115–120)	185	...	147	50	190	4	166	70	156	49	102	113	946	286

DETAILED RESULTS—*continued.*

SECTION "B" (HEAVY BREEDS)—TEAMS OF SIX BIRDS.

Name of Competitor and Birds Nos.	1st.	2nd.	1st.	2nd.	1st.	2nd.	1st.	2nd.	1st.	2nd.	1st.	2nd.	Totals. 1st.	Totals. 2nd.
E. Kerr (1–6)	231	...	187	...	231	1	228	14	252	...	11	1	1,140	16
F. Landquist & Son (7–12)	196	...	183	2	197	4	188	16	148	29	234	16	1,146	67
Cranleigh Poultry Farm (13–18) ...	207	7	166	...	150	31	178	...	219	1	86	94	1,006	133
Wyndella Poultry Farm (19–24) ...	233	15	224	9	225	4	198	2	175	56	220	1	1,275	87
A. S. Webb (25–30)	50	6	160	3	197	24	126	2	128	94	167	...	828	129
Robinson Bros. (1) (31–36)	223	1	149	26	142	105	147	...	212	23	174	8	1,048	163
Robinson Bros. (2) (37–42)	231	1	63	55	138	55	101	1	218	...	77	35	828	147
R. Harrison (43–48)	231	...	214	20	40	4	235	1	142	78	227	2	1,089	105
E. E. Price (49–54)	84	...	54	7	182	...	185	7	165	13	239	33	909	60
Mrs. E. E. Price (55–60)	165	3	166	15	145	3	199	3	48	3	172	6	895	33
Runnymede Poultry Farm (61–66) ...	191	...	126	58	210	10	244	11	173	2	21	170	965	251
M. H. Dadley (67–72)	283*	...	203	...	176	...	193	...	30	...	248	2	1,133	2
Mrs. M. H. Dadley (73–78) ...	95	146	70	175	202	66	226	14	162	7	206	40	961	448
R. A. Dusting (79–84)	215	9	200	10	193	1	179	3	86	23	89	5	962	51
Sudell & Sons (121–126)	166	1	206	2	159	...	66	102	190	3	203	11	990	119
Thorpe Poultry Farm (127–132) ...	274	6	245	...	235	3	175	1	114	...	210	6	1,253	16
Geo. Davey & Son (133–138) ...	200	2	170	53	180	44	68	139	209	1	149	10	976	249
N. T. Wilkinson (139–144)	202	22	122	98	218	4	203	46	200	16	183	15	1,128	201
Sundale Poultry Farm (145–150) ...	180	22	245	1	71	...	239	30	222	8	186	1	1,142	62
R. Caporn (151–156)	220	15	163	53	226	24	173	51	226	41	246	3	1,254	187
W. G. Hall (157–162)	214	...	262	9	191	60	170	2	185	82	78	5	1,100	158
M. Wall (163–168)	248	18	182	40	171	77	239	7	193	20	210	41	1,243	203

* Bird 67 (M. H. Dadley) was held at the College for the 365 days and completed a creditable performance by laying 300 First Grade eggs and no Second Grade eggs.

DETAILED RESULTS—*continued.*

SECTION "C" (MEDIUM HEAVY BREEDS)—TEAMS OF SIX BIRDS.

Name of Competitor and Birds Nos.	1st.	2nd.	1st.	2nd.	1st.	2nd.	1st.	2nd.	1st.	2nd.	1st.	2nd.	Totals. 1st.	Totals. 2nd.
Runnymede Poultry Farm (127–132)	64	2	126	...	89	...	136	3	131	23	125	4	671	32
Cranleigh Poultry Farm (133–138) ...	165	67	206	1	150	...	101	2	129	43	167	...	917	113
F. Landquist & Son (139–144) ...	181	7	168	...	210	3	129	91	87	...	189	2	964	103
R. Harrison (145–150)	129	20	151	39	183	...	186	...	135	8	127	63	911	130
Robinson Bros. (151–156)	63	130	73	82	86	8	180	3	136	...	188	7	726	230
G. Dolman (157–162)	136	61	172	15	180	25	122	22	153	11	130	24	893	158
J. N. Enston (163 168)	140	25	116	31	31	3	195	10	151	38	196	4	829	111

MORTALITY.

The following is a comparison of the deaths for 1936–37, 1937–38 and 1938–39 :—

	1936–37.		1937–38.		1938–39.	
	Deaths.	%	Deaths.	%	Deaths.	%
White Leghorns	6	6	7	7·3	8	6·4
Australorps	6	5·36	8	7·1	14	10·3
Rhode Island Reds	2	5·7	3	8	5	11·1

AVERAGES.

MONTHLY AVERAGES.

Month.	No. of Bird and Breed.	Total Number of 1st Grade Eggs Laid.	Average.	Total Number of 2nd Grade Eggs Laid.	Average.	Total Average for all Grades.
April	120 W.L.	1,269	10·57	224	1·86	12·43
	132 Aus.	2,076	15·73	159	1·20	16·93
	42 R.I.R.	576	13·71	220	·52	14·23
May	120 W.L.	1,758	13·16	16	·13	13·29
	132 Aus.	2,349	17·79	71	·5	18·29
	42 R.I.R.	625	14·88	3	·07	14·95
June	120 W.L.	1,195	9·95	140	1·16	11·11
	132 Aus.	1,704	12·91	379	2·87	15·78
	42 R.I.R.	485	11·54	80	1·90	13·44
July	120 W.L.	1,459	12·15	81	·67	12·82
	132 Aus.	1,912	14·48	225	1·70	16·18
	42 R.I.R.	636	15·14	46	1·09	16·23
August	120 W.L.	2,279	18·99	46	·38	19·37
	132 Aus.	2,619	19·84	199	1·5	21·34
	42 R.I.R.	783	18·64	58	1·38	20·02
September ...	120 W.L.	2,450	20·41	125	1·04	21·45
	132 Aus.	2,701	20·46	303	2·29	22·75
	42 R.I.R.	737	17·54	105	2·5	20·04
October	120 W.L.	2,439	20·32	212	1·76	22·08
	131 Aus.	2,678	20·44	238	1·81	22·25
	42 R.I.R.	642	15·28	148	3·52	18·80
November ...	118 W.L.	2,091	17·72	312	2·64	20·36
	130 Aus.	2,254	17·33	316	2·43	19·76
	42 R.I.R.	482	11·47	130	3·09	14·56
December ...	117 W.L.	1,823	15·58	373	3·18	18·76
	127 Aus.	2,086	16·42	337	2·65	19·07
	41 R.I.R.	...	...	...	...	...
January	117 W.L.	1,780	15·21	323	2·76	17·97
	127 Aus.	1,660	13·07	365	2·87	15·94
	40 R.I.R.	272	6·8	95	2·37	9·17
February ...	115 W.L.	1,406	12·22	199	1·72	13·94
	124 Aus.	1,432	11·54	295	2·38	13·92
	40 R.I.R.	294	7·35	94	2·35	9·7

YEARLY AVERAGES.

	1st Grade.	2nd Grade.	Average All Grades.
White Leghorns	166.1	17.2	183.3
Australorps	179	22.2	201.2
Rhode Island Reds	142.4	21.1	163.5

AVERAGE FOR ALL BIRDS IN TEST.

	1937-8.			1938-9.		
	1st Grade.	2nd Grade	Total.	1st Grade	2nd Grade	Total.
All birds ..	164.8	23.5	188.3	168.5	20	188.5

WINTER TEST RESULTS.

(1st April-31st July; 122 days.)

Winners.	No. of Eggs.	Average.
Light Breeds—E. Singleton, White Leghorns ..	400	66.6
Heavy Breeds—M. Wall, Australorps	496	82.6
Medium-Heavy Breeds—R. Harrison, Rhode Island Reds	398	66.3

LAYING AVERAGES FOR WINTER TEST.

(1st April-31st July; 122 days.)

	1st Grade.	2nd Grade.	All Grades.
Light Breeds—White Leghorns ..	45.84	3.75	49.59
Heavy Breeds—Australorps	60.91	6.32	67.23
Medium-Heavy Breeds—Rhode Island Reds	55.28	3.6	55.88

SUMMER TESTS.

(1st December-2nd March; 92 days.)

Winners—

Light Breeds—Leghorns. Mrs. E. E. Price; 353 1st Grade eggs, 1 2nd Grade egg.

Heavy Breeds—Australorps. Thorpe Poultry Farm; 275 1st Grade, 8 2nd Grade.

Medium Heavy—Rhode Island Reds—No award as no team reached 1,200 eggs.

SUMMER TEST—ALL TEAMS.

(1st December-2nd March; 92 days.)

	1st Grade.	2nd Grade.	All Grades.
Light Breeds—White Leghorns ..	43.55	7.78	51.33
Heavy Breeds—Australorps	40.1	.8	40.9
Medium-Heavy—Rhode Island Reds ..	23.3	7.04	30.34

Comparison of ten leading pens during the last three years:—

	1936-7.		1937-8.		1938-9.	
	1st.	2nd.	1st.	2nd.	1st.	2nd.
10 pens White Leghorns	960.8	21.7	1,074.6	8.06	1,106.6	54.4
10 pens Australorps	1,128.6	12.11	1,268.6	7.06	1,181.4	99.9
6 pens Rhode Island Reds	798.2	220.0	901.2	149.1	902.8	123

Rhode Island Reds entered for 1936-7 consisted of 5 pens.
1937-8 „ 6 pens.
1938-9 „ 7 pens.
each 6 birds.

The following birds which laid 200 or more first-grade eggs during the 48 weeks were awarded a sealed copper ring:—

COPPER BANDED BIRDS.

Copper Band No.	Trial No.	Breed.	Owner.	Number 1st Grade Eggs.
40	3	White Leghorn	E. O. Harrison	218
41	5	do. do.	do. do.	229
42	6	do. do.	do. do.	241
43	7	do. do.	S. Dolman	216
44	8	do. do.	do.	206
45	12	do. do.	do.	214
46	13	do. do.	W. R. Webb	225
47	17	do. do.	do.	222
48	20	do. do.	E. Singleton	209
49	24	do. do.	do.	201
50	44	do. do.	M. H. Dadley	204
51	63	do. do.	R. Harrison	209
52	64	do. do.	do.	221
53	73	do. do.	Mrs. E. E. Price	227
54	74	do. do.	do. do.	240
55	75	do. do.	do. do.	235
56	81	do. do.	H. P. Chalmer	236
57	88	do. do.	Robinson Bros.	227
58	89	do. do.	do. do.	206
59	90	do. do.	do. do.	230
60	91	do. do.	do. do.	202
61	92	do. do.	do. do.	204
62	93	do. do.	do. do.	221
63	98	do. do.	T. Gent	203
64	105	do. do.	H. Jager	227
106	1	Australorp	Mrs. E. Kerr	231
107	3	do.	do.	231
108	4	do.	do.	228
109	5	do.	do.	252
110	12	do.	F. Landquist & Son ...	234
111	13	do.	S. Dolman	207
112	17	do.	do.	219
113	19	do.	D. F. Robinson	233
114	20	do.	do. do.	224
115	21	do.	do. do.	225
116	24	do.	do. do.	220
117	31	do.	Robinson Bros.	223
118	35	do.	do. do.	212
119	37	do.	do. do.	231
120	43	do.	R. Harrison	231
121	44	do.	do.	214
122	48	do.	do.	227
123	54	do.	E. E. Price	239
124	63	do.	E. O. Harrison	210
125	64	do.	do. do.	244
126	67	do.	M. H. Dadley	283
127	68	do.	do.	203
128	72	do.	do.	248
129	75	do.	Mrs. M. H. Dadley ...	202
130	76	do.	do. do.	226
131	78	do.	do. do.	206
132	79	do.	R. A. Dusting	215
133	80	do.	do.	200
134	122	do.	T. Sudell & Son	206
135	126	do.	do. do.	203
136	127	do.	H. Seal	274
137	128	do.	do.	245
138	132	do.	do.	210
139	133	do.	Geo. Davey & Sons ...	200

COPPER BANDED BIRDS—*continued.*

Copper Band No.	Trial No.	Breed.	Owner.	Number 1st Grade Eggs.
140	137	Australorp	Geo. Davey & Sons	209
141	139	do.	N. T. Wilkinson	202
142	141	do.	do. do.	218
143	142	do.	do. do.	203
144	143	do.	do. do.	200
145	146	do.	A. Wilkinson	245
146	148	do.	do. do.	239
147	149	do.	do. do.	222
148	151	do.	A. R. Caporn	220
149	153	do.	do.	226
150	155	do.	do.	226
151	156	do.	do.	246
152	157	do.	W. G. Hall	214
153	158	do.	do.	262
154	163	do.	M. Wall	248
155	166	do.	do.	239
156	168	do.	do.	210
157	134	Rhode Island Red	S. Dolman	206
158	141	do. do.	F. Landquist & Son	210

In the above trial 78 birds qualified for copper rings, a percentage of 26.5 per cent.

Comparisons with previous years are as follow:—

	1936–37.	1937–38.	1938–39.
Number of Copper Rings awarded	69	75	78
	27·5%	30%	26·5%

The champion team was a pen of Australs entered by Wyndella Poultry Farm, Armadale.

The total of 1,275 first grade eggs was 213 eggs lower than the winner of 1937-38.

Mrs. E. E. Price, of Hilton Park, via Fremantle, won in the White Leghorn section. The team laid 1,261 first grade eggs, this being 4 in advance of the winner of 1937-38.

In the Rhode Island Red section F. Landquist & Son, of Talbot, via York, won with a team which laid 964 first grade eggs.

Bird No. 4 owned by Mrs. E. Kerr, of Wagin, laid a sequence of 167 eggs, but for official records she is only credited with 97. The laying was 69 two-ounce eggs, then one of 1 9/10th ounces, following with 97 two-ounce eggs.

FEEDING.

In addition to the trial birds being tested at the College, the Poultry Branch of the College were testing breeders for their own use and therefore the feed used at the trials must be considered as having been fed to 271 birds in 1936-37 and 248 birds in 1937-38 and 324 birds in 1938-39.

Feed Consumed:

	1936–37.	1937–38.	1938–39.
Wheat	190½ bushels	165½ bushels	224¾ bushels
Pollard	186 bushels	191 bushels	227¼ bushels
Wheat Meal	6,798 lbs.	6,469 lbs.	8,438 lbs.
Meat Meal	1,700 lbs.	1,962 lbs.	2,870 lbs.
Bran	207 bushels	178 bushels	244 bushels
Bonemeal	747 lbs.	990 lbs.	932 lbs.
	5·14 oz. per fowl per day.	5·13 oz. per fowl per day.	5·16 oz. per fowl per day.

The cost of feeding for the 48 weeks in the 1938-39 trial was £110 13s. 6d., or equal to 6s. 10d. per bird, while the net average return for eggs was 18s. 6d. The average profit was 11s. 8d. per bird.

Comparison:

	1936–37.	1937–38.	1938–39.
	s. d.	s. d.	s. d.
Cost of Feed	9 9¼	10 3	6 10
Average Gross Profit	8 10	9 2¼	11 8

Note: Feeding costs are based on the retail prices of all goods as charged by metropolitan produce merchants whilst the returns for eggs are those received in open sales less 5 per cent. selling commission and a deduction of an account sales fee of 6d. per day (a sum equal to £2 12s. per annum).

M. T. PADBURY TROPHY COMPETITION.

I. Thomas,
Superintendent of Wheat Farming.

With the finalising of the 1938-39 results, only one season remains before this competition closes. Inaugurated in 1930 and organised by the Royal Agricultural Society, this competition was made possible by a generous donation by Mr. M. T. Padbury, a pioneer farmer of the Moora district.

The trophy takes the form of a handsome shield, a replica of which is presented to the winner of each year's competition. The final award will be made on completion of the 1939-40 results to the competitor gaining the highest average yield per acre per inch of rainfall during the conventional growing period (May to October) for any five years during the period of the competition.

The winner of the 1938-39 competition was Hon. T. Moore of Indarra, with a splendid average of 4 bushels 9 lbs. over an area of 261 acres—this average has only twice been exceeded; by two competitors in 1934 with average yields of 4 bushels 29 lbs. and 4 bushels 13 lbs. He was followed by Mr. E. W. Prowse of Doodlakine with 2 bushels 42 lbs., and Mr. F. C. West of Toompup—the winner in 1936—with 2 bushels 36 lbs.

The conditions under which the competition is conducted are as follow:—

1. The competition will commence with the 1930-31 harvest and continue for a period of 10 years. At the end of that period the trophy will be awarded to the competitor who has taken part in the competition for at least five years, and who obtains the greatest mean average acre yield per inch of rainfall during the conventional growing period. The mean average yield will be computed from the results of the five seasons in which the competitor produced the highest acre-yield per inch of rainfall during the growing period. In the event of a tie the competition will continue between the leading competitors until an advantage is gained by one of them.

2. The conventional growing period for any year will be that decided upon and announced by the Royal Agricultural Society. For the first year, and until further notice, it was decided that it would be from 1st May to 31st October, inclusive.

3. Until the end of the competition the trophy will be in the custody of the Royal Agricultural Society, and will be displayed at any agricultural exhibition held by that society.

4. Each year the competitor who obtains the best average acre yield per inch of rainfall during the conventional growing period will be awarded a replica of the trophy. His name will also be inscribed upon a small shield affixed to the trophy.

5. The rainfall upon which the award will be made will be determined by the Commonwealth Meteorologist from the district records, and his decision in this matter will be final.

6. The competition will be limited to those farmers who harvest at least 200 acres of wheat for grain. Where a competitor is financially interested in the crops grown on one or more farms, he will be required to supply details regarding the production and marketing of the crops on same, and, though usually the award will be made upon the results from the farm nominated by the competitor, the Royal Agricultural Society may require that the crops on these farms be included in the competing area.

7. The average yield will be ascertained from the total area—including self-sown crops—harvested for grain, and determined from the actual amount of wheat sold, as shown by the delivery dockets, plus the amount retained for seed, for home use or for any other purpose.

8. The method of judging will be as follows:—At a convenient time the area harvested for grain will be measured and the quantity of wheat on hand ascertained. On or before 31st January the farmer will be required to furnish the judge with a sworn declaration as to the quantity of wheat sold from the competing holding or holdings, and the amount retained for seed and other purposes; the statement regarding the amount sold to be supported by agents' dockets. The judge, after satisfying himself as to the correctness of this statement, will compute the average yield per acre per inch of rainfall during the growing period from the information received.

9. The judge will be appointed by the Under Secretary for Agriculture and his decision will be final.

10. Nominations for this competition will be received by the Royal Agricultural Society up to the 31st October each year.

The results for last season (1938-39) are given in the table below:—

M. T. PADBURY TROPHY COMPETITION, 1938–39.

Competitor.	Address.	Rainfall during Growing Period.	Area Harvested.	Yield.				
				Gross.		Average per Acre.		Average per Inch Growing Period Rain.
		points.	acres.	bus.	lbs.	bus.	lbs.	bus. lbs.
Moore, Hon. T.	Indarra	576	261	6,239	43	23	54	4 0
Prowse, E. W.	Doodlakine	586	543	8,618	58	15	52	2 42
West, F. C.	Toompup /	1,020	200	5,281	15	26	24	2 35
Scadding, N. A.	Kulin	671	530	7,822	54	14	45	2 12
Barr, D. F.	Shackleton	846	612	10,673	52	17	26	2 4
Bremner, J. R. & Sons	Corrigin	821	882	13,821	36	15	40	1 54

The average yield per acre of the six entrants was 17 bushels 19 lbs., and the average yield per inch of rainfall during the growing period was 2 bushels 18 lbs.

CULTURAL DETAILS.

The winning crop entered by the Hon. T. Moore, of Indarra, was grown on land originally carrying York gum and jam, and was cleared in 1926. The 261 acres cropped were ploughed with a disc cultivating plough to a depth of 3 inches during July and August and cultivated with a springtyne cultivator in September and again in April.

The crop was seeded during May using a combined cultivator drill at the rate of 45 lbs. graded and pickled seed with 100 lbs. superphosphate per acre. Areas and varieties in the competition crop were Merredin 120 acres, Ranee 75 acres, Dundee 66 acres.

Of the 543 acres entered by Mr. E. W. Prowse, of Doodlakine, 29 acres were sown to Centenary, 107 acres to Noongaar, 177 acres to Totadgin, 40 acres to Bencubbin, and 190 acres to Gluclub. The land originally carried salmon gum, gimlet and mallee and was cleared over 15 years ago. It was scarified in July to a depth of 3 inches and again in September and October. During March and April the land was cultivated and seeding commenced in May. The rate of seeding was 40 lbs. per acre with an application of 90 lbs. of superphosphate. The combined cultivator drill was used for planting operations which were completed during May.

Mr. F. C. West's crop at Toompup which gained third place in the competition was grown mainly on old land originally carrying York gum, jam and yate. It was ploughed in June and July with a mouldboard plough to a depth of 2-2½ inches. A portion of the area—42 acres of new land was disc cultivated during August, the balance being springtyne cultivated during September and October, and again in March and April. Seeding at the rate of 55 lbs. of graded and pickled seed with 130 lbs. of superphosphate was carried out during early June with a combined cultivator drill. The competition area comprised 105 acres of Bencubbin and 95 acres of Free Gallipoli.

Mr. N. A. Scadding, of Kulin, had an area of 530 acres which included Gluclub (160 acres), Bencubbin (230 acres), Totadgin (60 acres), and Pusa (80 acres). The area consisted mainly of old land, 90 acres however were cleared in 1937. It originally carried blackbutt, morrel and salmon gum, and was ploughed to a depth of 3 inches with a disc plough in June and July. Further cultivation was given with a springtyne implement in September and October and again in April. During May, seeding was carried out at the rate of 60 lbs. seed and 120 lbs. superphosphate per acre, using a combined cultivator drill.

The crop exhibited by Mr. D. F. Barr, of Shackleton, consisted of 300 acres of Bencubbin, 200 acres of Glucub, and 112 acres of Noongaar. It was grown on land cleared in 1925-26 and originally carrying salmon gum, gimlet and morrel. Ploughed 4½ inches deep in June and July with a mouldboard plough, the land was subsequently cultivated in August and again before seeding. During April and May the area was seeded with 45 lbs. graded and pickled seed with 90 lbs. superphosphate per acre.

Messrs. J. R. Bremner & Sons' crop was grown on old land from which salmon gum, gimlet, jam and mallee timber had been cleared. It was worked in June and July to a depth of 3 inches with a rigid tyne scarifier. The scarifier was used again in August, followed by a springtyne cultivator in September and April. The whole area of 882 acres was sown with Bencubbin seeded during April and May at the rate of 50 lbs. seed with 145 lbs. superphosphate per acre with a combined cultivator drill.

In the table below are given particulars of those competitors who have taken part in the competition for four years and who are, therefore, eligible to compete for the final award to be made at the completion of the 1939-40 harvest.

M. T. PADBURY TROPHY RESULTS, 1930 1938 (INCLUSIVE).

Competitors who have Competed for four or more years.

Competitor.	Address.	Average Yield per inch of Growing Period Rainfall.								
		1930.	1931.	1932.	1933.	1934.	1935.	1936.	1937.	1938.
		bus. lb.	bus. lb.	bus. lb.	bus. lb.	bus. lb.	bus. lb.	bus. lb.	bus. lb.	bus. lb.
Allen Bros.	East Kumminin	2 11	2 23	....	2 26	3 1	....	....	....	....
Atkins, F. M. & J. L.	Jouerdine	2 41	3 0	....	3 39	4 29	....	....	....	....
Barnett, L. T. C.	Walgoolan	2 48	2 19	2 34	2 58	....	....	....	....	....
Barr, D. F.	Shackleton	1 49	....	....	....	....	....	1 54	2 17	2 4
Bremner, J. R. & Sons	Corrigin	1 55	2 10	1 48	2 32	2 37	2 12	1 49	2 13	1 54
Creagh Bros., Ltd.	Nungarin	2 20	2 16	1 43	2 12	2 41	....	....	2 7	....
Horsman H. & Sons	Bilbarin	1 53	2 6	1 5	2 49	....	....	....	....	....
Manuel, C. J.	Mukinbudin	2 44	2 10	2 5	2 5	3 4	....	....	....	....
Moore, Hon. T.....	Indarra	....	2 47	2 33	3 5	....	4 6	....	3 2	4 9
Nottage, R. B.	Tammin	....	2 36	2 21	3 23	4 13	....	....	....	....
Prowse, E. W.	Doodlakine....	1 42	....	1 31	....	3 13	....	....	....	2 42
Scadding, N. A.	Kulin	....	....	2 4	2 10	2 49	2 27	1 35	....	2 12
Stewart, W. B.....	Gnowangerup	1 52	2 37	1 54	2 55	2 30	....	....	....	....
Strange, P. A	Yarding	2 36	2 6	....	2 48	2 33	....	1 48	....	....
White, R. H.	Gnowangerup	1 51	2 45	....	2 40	2 47	2 25	....	....	....

THE PREPARATION OF THE SEED BED FOR WHEAT SOWING UNDER NORTH-EASTERN WHEAT BELT CONDITIONS.

W. M. NUNN, B.Sc., Agric.,
Agricultural Adviser.

From observations made during the judging of fallow competitions and from discussions with farmers of the North-Eastern Wheat Belt over several years, it appears that many wheat-growers in these areas—and probably also in others -do not recognise an objective to the workings they give the fallow. Land is fallowed and the fallow is cultivated for many reasons. To allow better soakage and conserve moisture, to kill weeds and protect the crop from disease, and to encourage the bacteria which prepare nitrates for use by the crop are benefits which are easily obtained by breaking up the surface soil and aerating it. But an equally important objective is the preparation of a suitable seed bed which will be in readiness for planting when the correct time and conditions arrive.

When a wheat grain germinates, it first of all sends out temporary rootlets from the grain itself and a shoot to the surface. On these temporary rootlets and on the food material stored within the grain, the young plant lives until several leaves are formed above ground. Then—and not until then—it thrusts out its permanent root system, and this system is always developed from the stem at a point about $1\frac{1}{2}$ inches below the surface of the soil where the plant emerges.

If the seed has been placed at a depth of, say, 3 inches, then it would mean that the plant has had to provide energy and growth— which could have been avoided by shallower planting—in growing first to the surface and then in thrusting its permanent roots downward again through two inches of soil, loosened by seeding operations, to the consolidated region below, from which it is to get its food and water supplies.

The ideal depth to seed is therefore at 2 inches—a little deeper than the 1½ inches mentioned above—because we have to allow for some settling down with the rains.

But whether you seed deep or whether you seed shallow it is even more important that the seed should be placed on a firmly consolidated seed bed. It is when the roots have to grope around in loose material before obtaining a hold in the firm material below that the plant is rendered susceptible to disease and to drought and, even with favourable conditions prevailing, it suffers a setback which delays its establishment and renders it less hardy throughout its entire existence. When dry conditions are obtained towards the end of the season it is the plant whose roots pass through loose material as a result of improper seed bed preparation which forms whiteheads most readily because, though there may be moisture enough in the subsoil to mature the grain, the upper regions of the roots have dried out with the drying of the loosened surface soil and they are unable to conduct the moisture to the above ground portions of the plant.

The ideal seed bed therefore is a compacted not hard level bed at a depth of 2 inches.

Very often soil conditions are such that a seed bed of this description is economically unobtainable. Stiff heavy clay soils do not break down readily and in the dry seasons much of the work has to be done while the land is in an unsatisfactory condition for breaking down.

In some cases such a seed bed as has been described may be inadvisable. On hillsides where surface wash is expected with the first rains it is often safer to leave a deeper mulch to ensure rapid soakage, the cultivation following the contours.

Each farmer, however, in preparing his fallow, should aim at the preparation of a definite seed bed and not at merely breaking up the soil and eliminating the weeds.

How is this objective obtained?

Farmers are now unanimously agreed that the land should be broken up as early as possible in the winter of the fallow year so as to allow the maximum soakage. This is very generally done throughout the lower rainfall wheat areas to a depth of 3-4 inches and it is in subsequent cultivation that methods vary. Naturally, with different classes of soil different methods are required to bring about the same result, but in one important aspect—that of depth—we can generalise. If the land has been ploughed 4 inches deep, then the cultivations in spring should be to this depth. A tyne cultivation is preferred at this time of the year as its effect is to comb the soil and sift the fine material downward while the clods are thrown to the surface. This is the first step in the preparation of the seed bed and it will be readily seen that if this cultivation were a shallow one, the machine would ride over the top of much of the cloddy material and subsequent compaction would be very difficult.

The fallow thus enters the summer period with the finer material at the bottom of the ploughed region. Summer rains and the trampling of stock still further compact this layer.

Cultivations after autumn rains and prior to seeding should be to a depth of 2 inches and should be done with a properly adjusted tyne implement which will cut to a level surface. Thus a seed bed is formed above the fine material which was sifted down in the spring cultivation and consolidated throughout the summer. The weight of the implement still further compacts this bed during autumn cultivation.

It has been shown by experiments at the Research Stations and observations elsewhere, that cultivations after summer rains are not economical so long as weed growth can be kept down by grazing. Should a cultivation be given, however, it should be only to a depth of 2 inches so as not to disturb the consolidation taking place below that depth.

The points to be emphasised, therefore, in a generalisation are:—

1. Fallow early.
2. Cultivate in spring with a tyne implement to the *full* depth of the ploughing.
3. Keep weeds down and assist consolidation by grazing.
4. Cultivate after autumn rains and prior to seeding with a properly adjusted tyne implement to a depth of 2 *inches.*
5. At seeding see that the seed and super are planted *on* the seed bed so formed.

SOME FACTORS AFFECTING SEED POTATOES.

E. T. MORGAN,
Officer-in-Charge, Potato Branch.

Western Australia is unique in the fact that practically one variety of potato only is grown throughout the producing areas of the State, namely, the "Delaware." The question which often arises in other countries, where many sorts are usually produced, "Which variety shall I grow?" is therefore seldom asked.

The "Delaware," which was introduced into this State from the United States of America in about the year 1910, has proved itself to be a wonderfully consistent cropper and does well at all times of the year in our varying classes of soil. There is, in my opinion, a great merit in having only one variety, as it is reasonable to suppose that one variety can be maintained in a greater degree of health than is possible in dealing with a large number of varieties. The various virus diseases manifest themselves differently in different varieties. therefore a multiplicity of symptoms would be discernible when many kinds are grown, thereby complicating to a great extent the preservation of even relative freedom from such diseases.

In the past, it has been the common experience of potato growers in nearly all parts of the world that, sooner or later, varieties have degenerated to such an extent that they became unprofitable. It has often been heard that potatoes have "run out," and this degeneration has been greater in some varieties than in others. It is interesting to note that some of the present-day popular varieties were introduced many years ago. For instance, the Brownell's Beauty, which is the favourite variety in Tasmania, was first produced in the year 1873, while our Delaware was produced in America in 1888. Some varieties have been found to have degenerated in a comparatively short space of time.

Following the introduction of the Delaware variety into this State, little trouble in our seed stocks was noted, in spite of the fact that little or no selection was made, and small or "round" seed was mostly used. After a while, many growers, working on the assumption that "like produces like," used large tubers and cut these into sets for planting, and improvement in crops was noted. About 18 years ago, however, it became noticeable that, in spite of this apparent selection, all was not well with our stocks, as various plants in fields showed curly leaves and stunted appearance. Some growers went a step further in

selection and dug out apparently healthy, well-grown plants, saving the tubers for seed purposes, but even then some signs of trouble were still noted. About this period, literature from other parts of the world stated that virus diseases were increasing and mosaic and leaf roll, two types of these diseases, were described.

It was thus possible, with the aid of the Plant Pathologist, for us to begin to assign the reason for the degeneration of stocks. There is, at present, much research work going on in relation to virus troubles and in America many different forms in the potato are recognised. In this State, however, mosaic and leaf roll are mostly in evidence, the first-named manifesting itself in a mottling and crinkling of the foliage, and the latter in a general dwarfing of the plant, with a rolling of the lower leaves, the plant yellowing prematurely, and the yield from these plants being greatly affected.

These diseases live in the sap of plants, and are not arrested by sprays or other treatments which are effective in controlling other diseases in plants. Unfortunately, these virus troubles are transmitted from unhealthy plants by such sucking insects as aphids, thrips, leaf hoppers, etc., to healthy plants. This is the reason why, when the lifting of apparently healthy plants and the tubers from these have been planted, that the succeeding growth has been found to be affected with disease. It will thus be seen that if we are to maintain the productiveness of our stocks, great care in selection is necessary; the only control of these diseases is by the eradication of the diseased plants in our seed plots as early as possible.

In 1926 the Government Certified Seed Potato Scheme was introduced, and by the use of such seed, the virus disease infection has been kept at a minimum. About this period, seed stocks in the South-West were so badly affected that yields in many cases were reduced to 2 tons and less per acre. The introduction of "certified" seed from the Great Southern area, the Denmark, Young's and Kalgan River districts especially, revolutionised the industry in the South-West, and to-day such seed and its near progeny has continued to give excellent crops, our high average of more than 5 tons per acre speaking for itself.

The improvement of the potato by selection is a field of endeavour in which every grower interested in the problem of increased production per acre can engage, but it is practically impossible for the grower to maintain freedom from disease in the commercial plot. This can only be done effectively in a special seed plot which should be well isolated from possible infection from a commercial area, a minimum distance of 200 yards should be allowed from other growing potato plants. The best and only reliable time to establish the seed plot is in the winter, as any virus diseases are more easily determined in colder weather, high temperatures such as are experienced in the summer-grown crop have the effect of somewhat masking these diseases, the symptoms do not show so readily, and greater difficulty is experienced in detecting and eradicating affected plants.

Again, in the colder weather, insects such as aphids and thrips are not so plentiful and the risk of transmission of disease is minimised. This is the reason why, in other countries, it is usual for seed to be purchased from colder parts for planting in warmer areas, such as seed being bought in Scotland for planting in England, and much of the seed in the United States of America, from Canada. In these countries, one main crop per year is planted, while in this State potatoes are grown practically all the year round, and it is thus possible for us to establish seed plots at that time of the year where practice has taught us that best results are obtained.

In the establishment of the potato stud seed plot, it is desirable that the seed shall be taken from apparently healthy, well-grown, true-to-type and heavy-yielding plants, and preferably from the heaviest type of land in our swamp or

summer land. These plants could be staked or marked in some way during the growing season, avoiding, if possible, the staking of any plants in the near vicinity of any other showing mottling or crinkling of the foliage and dwarfed and leaf rolled plants. It is good practice to keep the tubers from each root separate, these can then be planted separately in the seed plot, allowing a small space between each planted root of tubers, so that any plants which may have picked up infection in the growing stage will be together, and eradication of the whole series of roots carried out. A further and more elaborate method that can be adopted in the seed bed is what is known as the tuber unit system. Selection is made as quoted, but instead of each root being separated, each tuber is treated as a separate unit. Each potato is cut into sets, if large enough for cutting, and the sets from each tuber are planted consecutively, allowing a double spacing between this unit and the next, and so on, until the seed bed is planted.

This latter method has been introduced in connection with the certified seed scheme, the first plot being planted in the Denmark area in August, 1937. In this area, such a procedure as a measure for good seed production, is a practicable proposition because only quite small areas are grown in this so-called winter planting. It is usual to employ planting boxes when sowing the crop, so that the sectioning of such planting boxes is easy. A half fruit case (flat) can be divided into six sections, and a kerosene case cut through on the side can be divided into 12 sections. It is thus possible to cut a tuber into each section and planting can be carried out with little loss of time.

The tubers from this crop, after effective "rogueing," are again sown in about March (autumn planting), which crop is harvested in July and August, and this provides seed for the main swamp crop planting in November and December and harvested in March and April, and which supplies certified seed, available for main crop planting in the South-West areas during June, July, and August.

This method allows us, in the case of any of the plants in any unit being affected with disease, to wipe out the whole of such unit. It is desirable to wipe out any unit that shows even one plant to be affected, as it is possible that part of a tuber may be badly affected and easily recognisable, whereas other parts of the same tuber may be affected in a lesser degree, and be not easily discernible, so that by the eradication of each complete unit we shall stand a reasonable chance of obtaining disease-free stocks. By this method badly affected stocks have been cleaned up in a short time.

It may seem strange that one part of a tuber can be affected more so than another, but, according to research work done in various parts of the world on the transmission from diseased to healthy plants, it appears that something like 18 days must elapse before disease reaches the tubers after the inoculation of the plant. It will thus be seen that progress is slow and explains why some tubers or even part of a tuber on the same root are effected, while others appear to remain healthy. The crop may come to maturity and be harvested prior to all tubers becoming affected. Once we have obtained good seed, it is possible, with care and attention, to keep it productive over a number of years, especially if we can grow under sufficiently isolated conditions, so as to avoid contamination from other crops that may be diseased. It is practically impossible to keep our seed perfect, but if a grower takes all precautions he has a reasonable chance of maintaining it at a high degree of freedom from these virus diseases.

Another problem we are faced with in our seed tubers in summer-grown crops is so-called "thready eye," or "spindle sprout." This shows itself in the failure of the tuber to produce a normal shoot, but a thin thread-like growth is sent out from the eye and, when the potato is planted, this weak shoot seldom

emerges above the ground. This trouble has been found to occur in tubers grown mostly in the light sandy peat swamps in the Albany and other coastal districts. Unfortunately, no symptoms are noticeable in the growing plants, and it is often found in the larger tubers from well-grown plants.

No special work has been done in this State on this trouble, but observation tends to the belief that this result is brought about by lightness of soil and high temperatures during the time when the crops are coming to maturity. This observation is strengthened by the fact that the larger tubers are generally affected, while little is noted in the smaller potatoes. It is usual for the larger tubers, in any potato crop, to be found near the surface, and these would be more affected by heated conditions, while the smaller tubers generally found lower down on the same roots, being often in moister soil, are not so affected and little trouble is noted.

It would therefore appear that heated conditions at some stage of the growing period impair the vegetative vigour of the seed tuber for future planting, for it has been noted that where heavy crops of greenstuff have been ploughed in, so increasing the humus content of the soil, thereby minimising extreme difference of soil temperature, that this trouble has been very considerably reduced. This ploughing-in of green crops is, therefore, advocated in an attempt to control this trouble.

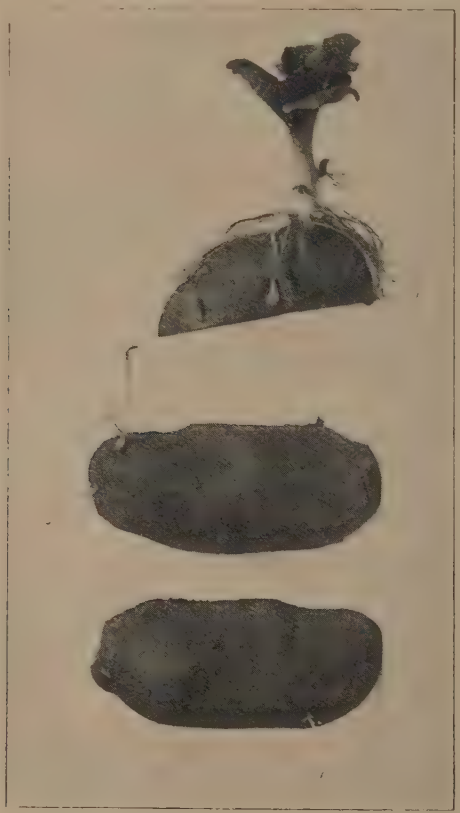
Experimental work in the production of seed in the southerly parts of America where temperatures are high, have demonstrated that a mulch of straw or other litter was found effective in increasing the vigour of the seed, which again tends to show that seed is obviously affected by extreme heat. Whilst this is practicable in a small seed plot, it would be difficult on a large area.

The following photograph shows tubers which were taken by myself from a single plant and planted with results as shown. The "sets" from the large tuber show "thready eye" sprouts, while the other shows a large, healthy, sturdy shoot. I am not forgetting the possibility of virus disease in such a case, but this appears rather improbable on account of the fact that I can instance that seed from the same plot has been planted on different locations with the result that from one soil type so-called "thready eye" has shown prominently whereas in the other case no such trouble has occurred. Seldom, if ever, do we find this trouble from tubers grown in heavy soil types when the crop comes to maturity under reasonably cool weather conditions.

As well as thready eye, a certain lack of vigour in seed which has been produced in light soil types has been noted. Such, when grown alongside seed which has been produced in heavy soils, has failed to give corresponding crops and yields have shown 1 to 2 tons per acre in favour of the heavy soil type seed. When this unthrifty seed is again grown in heavy soils, if free of leaf roll and mosaic, a pick-up in vigour is noticeable. This weakness may be bound up in lack of certain nutrients required by the plant and tubers, and it was suggested to me early in 1937 by an officer of this Department, that copper may be needed in order to build up the vigour of the seed. Recent experimental work in the Albany area in conjunction with the Plant Nutrition Officer (Dr. L. J. H. Teakle) and observations have tended to support this theory.

It has been stated by many growers that the use of immature seed results in heavier yields, but it is hard to understand why, when seed of almost any other plot should be fully developed, the potato tuber should be treated differently. Experiments conducted in various parts of the world have, however, indicated that the planting of immature seed has been attended by heavier yields, while other experimental work has shown that no advantage has been gained by its use. Advocates of immature seed aver that for the production, the proper

water and nitrogen contents of the tubers are obtained just about the time the tops show the first signs of ripening. The evidence in favour of unripe seed is so strong that one cannot lightly disregard it, but recent work has shown that a crop lifted in an immature state is not so long exposed to virus disease infection as is one which is allowed to ripen completely. It may be stated, therefore, that the one important advantage of using immature seed may be due to com-



"Sets" from tubers from a single plant. One "set" is showing a normal "shoot" and the other two show thready eye sprouts.

parative freedom from transmitted diseases and that evidence points to the immature seed being less vigorous than ripe seed when diseases are absent. It will also be readily appreciated that the storage of seed, which has to be done for some considerable period in the Great Southern areas, will be more successful when the tubers are well ripened before being harvested.

It has been discovered that where black spot or "early blight" makes its appearance in the potato tops, as it often does in autumn-grown seed crops, if the tubers are dug on the green side so-called storage trouble develops, but where the potatoes are thoroughly ripe when harvested, little damage ensues during storage.

(To be continued.)

PASTURE SPECIES TRIALS.

H. G. Elliott, Agrostologist.

The State Committee of the Australian Dairy Produce Board Pasture Improvement Committee (W.A.), during 1937, made further funds available to be used for initiating demonstrations under dry land conditions with a view to showing the value of various grass species under controlled methods of grazing.

The State Committee decided, as in the case of the initial experiments being conducted under irrigated conditions on the properties of Messrs. A. E. Jackson, of Roelands, J. Neil, of Waroona, and C. H. Henning, of Hamel, to co-operate with the Department of Agriculture in establishing two further experimental areas on the properties of Mr. A. A. Millar, of Forest Grove, and the Denmark Research Station.

1.—DENMARK RESEARCH STATION.

The area of 10 acres, when taken over in May, 1937, was mainly under subterranean clover and annual grass species such as brome, spear, silver and barley grasses, and in odd patches *Paspalum dilatatum*. By June, 1937, the complete area was ready for sowing, and on the 17th of that month all species were sown.

Cultivation.—The land was first ploughed to a depth of about 4in. and allowed to remain in fallow for approximately three weeks; it was then re-ploughed and worked down thoroughly with a cultivator so that a firm seed bed was formed. The area of 10 acres was divided into five fields, each field being two acres in extent.

The objects of the experiment included—

(1) To determine the most suitable grass for the establishment of a permanent pasture under dry land conditions on the soil type selected in this area.

(2) The collection of information regarding the carrying capacity of these grasses on small areas.

(3) To determine the best method of managing to incorporate grass species.

Soil.—Practically all the soil on Plots 1, 2, and 3 consisted of loamy sand and some brown gravelly sand, while on Plots 4 and 5 the soil type consisted mainly of sandy grey and brown gravels, together with some sand and loamy sand soil types. The area on Fields Nos. 1, 2, and 3 had a tendency to become water-logged in the winter. The original timber consisted of jarrah and red gum, and the whole area on Fields 1, 2, and 3 was heavily infested with bracken fern. During the winter of 1937 some drainage was carried out to relieve surplus water on Fields 1, 2, and 3.

Seed Mixtures.—The seed mixtures sown during mid-June were as follows:—

Field No. 1—South Australian Certified *Phalaris tuberosa*—4 lbs. per acre.

Field No. 2—Victorian Certified Clunes Perennial Rye Grass—8 lbs. per acre.

Field No. 3—New Zealand Yorkshire Fog—4 lbs. per acre.

Field No. 4—New Zealand Certified Italian Rye Grass—8 lbs. per acre.

Field No. 5—New Zealand Commercial Perennial Rye Grass—8 lbs. per acre.

The whole area, prior to cultivation, had been growing the mid-season variety of subterranean clover. With Fields Nos. 4 and 5, however, a very heavy cover of annual grasses occurred, as this area was much older than that of the other three fields.

Fertiliser.—Two hundredweight of superphosphate and ammonia No. 3 per acre was applied at the time of planting. A further 1 cwt. per acre was applied during late September (1937), giving a total of 3 cwt. per acre over the complete area for the first season. The fertilising rates for 1938 consisted of 2 cwt. of superphosphate in the autumn, plus 1 cwt. in the spring. A further application of 2 cwt. per acre has been given during May, 1939.

Germination.—Generally the germination of the grass species on fields was good. Owing to the late planting, however, very little clover grew over the area for the first year. After the early autumn rains in 1938, excellent growth of subterranean clover occurred on all fields. The *Phalaris tuberosa* in Field No. 1 gave exceptionally good germination, and showed vigorous growth in the early part of the season. With the Clunes perennial ryegrass, however, which was sown in Field No. 2, the germination was satisfactory, but there was practically no clover growth. The Yorkshire fog in Field No. 3 gave a very high percentage of germination, and by September had given practically a full ground cover, the plants all being very vigorous. In Field No. 4 the Italian ryegrass gave a reasonable germination, but was suppressed to a great extent by the heavy growth of minor annual grasses which had grown very vigorously during the spring months. Owing to the unpalatability of these annual species during the time they are flowering, very little control by grazing could be obtained, and the complete area in Fields Nos. 4 and 5 had to be mown in an attempt to reduce the stand of these grasses. The same condition as given for Field No. 4 prevailed for Field No. 5, commercial perennial ryegrass.

Bracken Fern.—To assist in controlling this fern, the complete area on Fields Nos. 1, 2 and 3 was mown in September, 1937. This was again carried out in March, 1938.

Grazing.—The grazing obtained from all fields during the first season was practically equal, being 22 grazing days of 8 hours per month per acre with dairy cows.

CONDITION OF FIELDS—1938.

Field No. 1.—During the year, the *Phalaris tuberosa* became fairly well established, with the crowns of the plants greatly increasing in diameter, and owing to the vigorous growth of clover which occurred during the season, the leaves of the *Phalaris* showed good colour, and the plants were generally vigorous. During the winter, however, the plants had a tendency to show yellowness on the tips of the leaves, this being attributed to the excess wetness of the ground during that time.

Field No. 2.—Clunes perennial ryegrass—Generally the plants were vigorous and showed a healthy green colour. Owing, however, to the extremely dry summer which occurred, there was a tendency for the ground cover over the area to be patchy.

Field No. 3.—Yorkshire fog—On the sandy and sandy-loam types of country it is well established, but on the more gravelly soil there was a tendency for a number of the plants to die out during the first summer.

Field No. 4.—The Italian ryegrass practically disappeared after the first season, and at the end of 1938 only a few scattered plants could be observed throughout the field.

Field No. 5.—The Commercial ryegrass in this field has practically gone out. Only in isolated places can any of the plants be found.

General.—Owing to the heavy rainfall of 7½ inches which occurred in January, 1939, the subterranean clover germinated freely on all fields, and the following

dry spell killed back the majority of the plants. The *Paspalum dilatatum* is gradually increasing over all plots, more particularly on the lower end of Fields Nos. 4 and 5. The complete area was mown in January, 1939, to again assist in controlling the bracken fern. The grazing obtained for 1938 was as follows:—

Field No. 1—135 grazing days per acre.
Field No. 2—122½ grazing days per acre.
Field No. 3—154½ grazing days per acre.
Field No. 4—183 grazing days per acre.
Field No. 5—135 grazing days per acre.

In January, 1939, it was decided to completely clear all the standing timber off Fields Nos. 3, 4 and 5. This operation has now been completed.

2.—A. A. MILLAR, FOREST GROVE.

As was the case with the Denmark Research Station, 10 acres of land was selected and divided into 5 2-acre fields. The area was taken over in April, 1937. Prior to the establishment of the species in this area, the pasture consisted mainly of subterranean clover, drooping flowered clover and minor annual grasses. By May, 1937, the complete area was ready for sowing and early in June, 1937, all species were sown.

Soil.—The soil consisted of red karri loam, which was previously timbered with karri and red gum. It was first partially cleared in 1925, and after a few years under subterranean clover, was cropped with maize. This crop was followed with oats and peas.

Cultivation.—The first ploughing was delayed to allow the weed and existing pasture seeds to germinate. These were ploughed in and the land well worked down prior to sowing.

The objects of the experiment were the same as those given for the Denmark Research Station.

Condition.—By the end of June, all species were showing an excellent germination, with the exception of Yorkshire Fog, which was a little slower than the other species. The ground, however, was very wet, due to the exceptionally heavy rains in the earlier part of the season, *i.e.*, 24 in. in three months. However, there was no surface water showing on the ground, which was, nevertheless, in a soggy condition.

Seed Mixtures.—The following seed mixtures were sown:—

Field No. 1—Commercial Perennial Ryegrass—6 lbs. per acre.
Field No. 2—New Zealand Yorkshire Fog—4 lbs. per acre.
Field No. 3—New Zealand Italian Ryegrass—8 lbs. per acre.
Field No. 4—South Australian Certified *Phalaris tuberosa*—4 lbs. per acre.
Field No. 5—Victorian Certified Clunes Perennial Ryegrass—8 lbs. per acre.

Fertilizer.—2 cwt. of superphosphate and ammonia No. 3 was applied at the time of planting. A further 1½ cwt. of superphosphate was applied in the early spring. The fertilizer rate for 1938 consisted of 2 cwt. of superphosphate in the autumn plus 1 cwt. in the spring. A further application of 2 cwt. per acre has been given in April, 1939.

Germination.—Generally the germination over all plots was good. Owing to the late ploughing, however, very little clover established itself during the first year. Unfortunately a fair amount of cape-weed grew and, more or less, took charge of the complete area in the earlier stages. The cutting or grazing off could not be carried out owing to the softness of the ground. This weed infestation affected the ultimate stand considerably.

The following table gives the cow grazing days (8 hours) per acre for each field for the year 1938:—

Field No. 1—Commercial Perennial Ryegrass ..	25.8	grazing days
Field No. 2—N.Z. Yorkshire Fog	14.5	„ „
Field No. 3—N.Z. Italian Ryegrass	17.0	„ „
Field No. 4—South Australian *Phalaris tuberosa*	28.0	„ „
Field No. 5—Vict. Clunes Perenial Ryegrass	31.6	„ „

General.—The *Phalaris tuberosa* on Field No. 4 showed a decided improvement in vigour and development of plants over the initial year, 1937. Clunes Victorian Perennial Ryegrass is now well established and is far superior to the Commercial and Italian Ryegrass fields. Subterranean and Drooping Flowered clovers have re-established themselves over all fields and gave good growth during 1938.

To Mr. V. E. Randall, Manager Research Station, Denmark, and Mr. J. M. Nelson, Dairy Supervisor, Vasse, I am indebted for obtaining most of the field information given in this article.

THE SOILS OF THE 3,500 FARMS SCHEME AREA, WESTERN AUSTRALIA.

L. J. H. TEAKLE.

Summary.

1. The structure of the 3,500 Farms Scheme of Western Australia, as one of the post-war land settlement schemes in the British Empire, is briefly discussed.

2. The diagnosis of soil salinity as the major contributing cause of abnormally low wheat yields in the Salmon Gums district led to a reconnaissance of the portion of the scheme lying in the triangle which has Salmon Gums, Newdegate and Southern Cross as its apices.

3. A brief description of the general geological, vegetation, climatic and soil factors is given. The climatic factor is suitable for wheat growing and sheep raising, and the woodland and mallee soils, on which the settlement was to be based, were found to belong to the zone of grey and brown solonised soils of the present wheatbelt.

4. Examination of soil samples from 650 sites showed the woodland soils to be affected by a degree of soil salinity unusual in the wheatbelt generally, but comparable with that at Salmon Gums.

5. On the basis of profile features the woodland soil types were segregated into 6 groups and the analyses considered in relation to these groups. It was found that the heavier textured soils were most seriously affected by salinity while the lighter textured types could generally be regarded as "safe."

6. Using the conclusions from later surveys, it is estimated that about one-fifth of the area of woodland soils would be excessively saline for wheat production.

7. If the powdery morrel soils are included with the excessively saline soils, about one-third of the area of woodland soils would be more or less unsuitable for wheat production.

8. It is suggested that, from the soil point of view, agricultural development would be possible in the light of a knowledge of the nature of the soil types of the area and the results of many years of farming experience and agricultural research in the Salmon Gums and other districts.

Introduction.

Perhaps the most ambitious post-war land settlement project in Australia was that popularly known as the 3,500 Farms Scheme, which was suggested by the Western Australian Government and adopted for investigation by the Development and Migration Commission. As part of the rehabilitation programme after the war of 1914-18, the British and Australian Governments entered into an agreement for the absorption of British migrants and their establishment on the land with the object of more suitable adjustment of primary and secondary industries and appropriate distribution of population within the Empire as an economic unit. In 1922 the British Parliament passed the Empire Settlement Act which empowered the Secretary of State to formulate and carry out schemes, in association with Dominion Governments and other authorities, for settlement in overseas Dominions of suitable people in the United Kingdom. This Act is to run until 1952. Under it, the Secretary of State entered into an agreement with the Commonwealth of Australia in April, 1925, for the spending of £34,000,000 of British loan money to initiate settlement and to improve facilities in settled areas, and so promote development and expansion. Working conditions were established and were largely directed to the absorption of migrants.

The following year the Commonwealth Parliament passed the Development and Migration Act of July 21, 1926, to implement the agreement with the British Government. Under this Act four Commissioners, headed by Sir H. W. Gepp, were appointed with wide powers and functions and, among other responsibilities, were charged with the thorough investigation of all schemes submitted by the States under the Migration Agreement. This Board was critical, yet constructive, and made every use of expert advice in the consideration of projects placed before it. They required the best factual basis for all propositions and lent every assistance in the collection of data necessary for the proper evaluation of all schemes submitted. From their reports may be obtained information concerning the various projects for development brought under the notice of the Commission, and it is some consolation that the Western Australian 3,500 Farms Scheme was not the only one failing to meet with final approval.

The 3,500 Farms Scheme.

Practically the only large area of wheat lands in a suitable climatic zone not then settled in Australia, was in this State and lay—

(a) South of Southern Cross and between Newdegate and Salmon Gums.

(b) North of the Lake Brown loop railway and east of the southern portion of the Wongan Hills-Mullewa railway.

It was estimated that the first section, covering about 7,000,000 acres between Newdegate and Salmon Gums constituted seven-eighths of the total area available and would be most suitable for the opening up of the scheme. (The location of this area is shown on the map in Fig. 1.) Consequently, the land was rapidly classified by surveyors, largely on the basis of vegetation types which had proved generally satisfactory in other parts of the wheatbelt, and subdivision into blocks suitable for wheat and sheep farming commenced. It was expected that about 3,000 farming units, based on the first-class land available, were possible in the area and that 1,000,000 sheep would be carried in addition to cropping 1,000,000 acres to wheat annually. The estimated yield of wheat was 12 bushels per acre. Railways, roads, water supplies, schools, etc., and harbour facilities were to be provided at an estimated cost of over £5,000,000 and a like sum would be required for the settlement of migrants on the individual holdings. The world's markets for wheat and wool appeared to offer splendid prospects and the scheme seemed

economically and socially sound. Of course, the collapse of wheat prices in 1929 was not anticipated by anyone.

The first misgiving arose from a consideration of the wheat returns from the Salmon Gums district which bounded the scheme on the east. This district since 1914 had fairly consistently failed to attain the State average yield per acre and the most unsatisfactory returns had been obtained since 1922 when settlement of

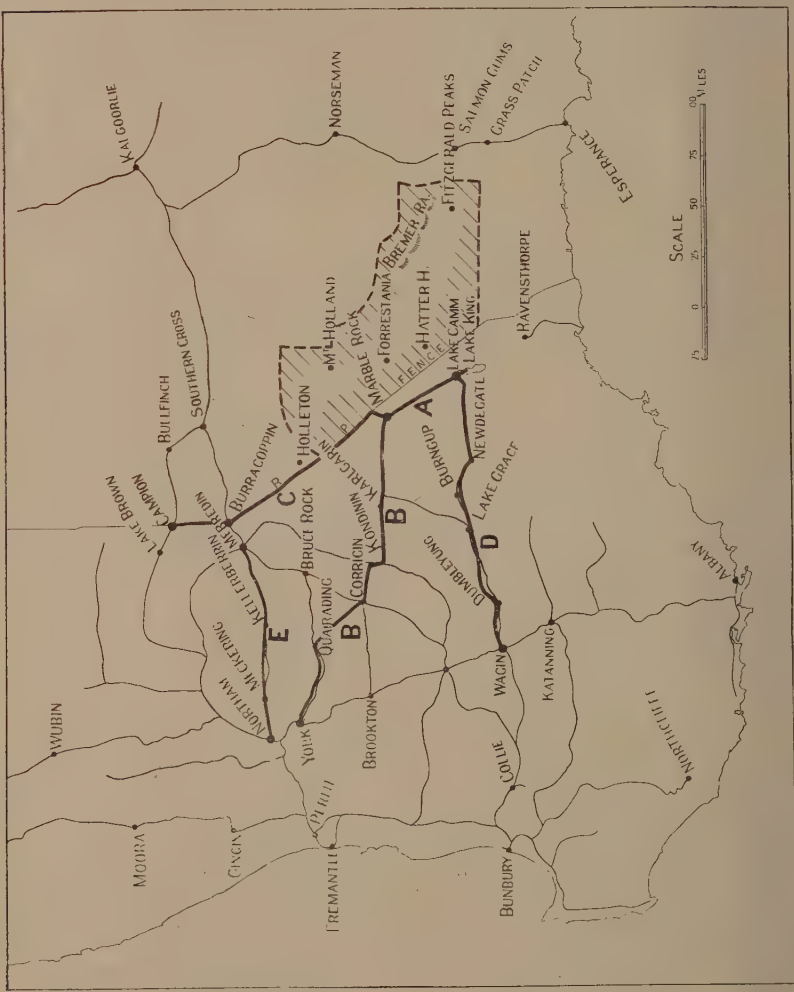


Fig. 1.—Map of south-western portion of Western Australia, showing the location of the portion of the 3,500 Farms Scheme investigated, and of traverses made to ascertain the conditions in the settled parts of the wheatbelt.

the district had begun in earnest. The main reasons advanced, namely, unsatisfactory settlers, "sour" mallee land, and poor methods, failed to satisfy the Commission. A comparison of the yields of wheat per acre for the State and for Salmon Gums is given in Table 1.

Table I.

Comparison of Yields of Wheat per acre for the State and the Salmon Gums District, 1914 to 1930.

Year.	Salmon Gums District.	State.
	Bushels per acre.	Bushels per acre.
1914	2·5	1·9
1915	5·3	10·5
1916	9·6	10·3
1917	10·1	7·4
1918	2·9	7·7
1919	6·2	10·8
1920	10·8	9·6
1921	8·3	10·4
1922	6·6	8·9
1923	3·1	4·4
1924	4·0	12·8
1925	4·2	9·7
1926	6·9	12·1
1927	7·8	12·1
1928	3·6	10·1
1929	7·2	11·0
1930	9·5	13·5
Average (1914–1930)	6·4	9·6
Average (1922–1930)	5·9	10·5

It was evident that, if the Salmon Gums area were representative of the unoccupied land to the westward, a 6 bushel average could be expected instead of the estimated 12 bushels on which the scheme was based. The writer was requested in 1929 to investigate the situation at Salmon Gums with a view to ascertaining the cause of the unsatisfactory yields.

Investigation in the Salmon Gums District.

In May, 1929, a visit was paid to the Salmon Gums district. It was observed that the soils of the district fell into three main classes:—

1. Sandy surfaced types with a calcareous clay subsoil.
2. Heavy textured or clay types which were generally characterised by crab-holes or gilgais.
3. "Kopi"* types related to the powdery morrel soils or other districts.

While patches of timber occurred throughout the district (and hence the name Salmon Gums), the prevailing vegetation consisted of stunted eucalypts and mallees associated with tea trees (*Melaleuca* spp.) and a variety of shrubs.

Through the courtesy of the Manager of the local Branch of the Agricultural Bank (Mr. H. F. Rodgers) an inspection of the cropped soils of the district was made. It was found that many instances of crop failures or poor returns were directly correlated with soil salinity. It seems that, in many instances, in which disappointing returns were being obtained, the first crop, often roughly sown on the burn, had been quite good, averaging, perhaps, 5 bags per acre, while subsequent crops, put in under more approved farming conditions, had yielded only as many bushels. The heavy textured "gilgai" country and the "kopi" types were most generally associated with the crop failures and it was evident that the "safe" soils were the sandy-surfaced types.

* Kopi is a native term properly applied to deposits of whitish floury gypsum but, in the Salmon Gums district, it is used popularly for the light grey or whitish calcareous soils of the powdery morrel type.

TABLE 2.

Distribution Table showing the incidence of Soil Salinity in Virgin Country and the Relationship between Soil Salinity and Growth of Crops, Weeds, etc., in the Salmon Gums District, June, 1929.

Depth.	Percentage of Samples in each range of total water soluble salt concentration* expressed as per cent. in dry soil.												
	·05 and below.	·05 to ·10.	·10 to ·20.	·20 to ·30.	·30 to ·40.	·40 to ·50.	·50 to ·60.	·60 to ·70.	·70 to ·80.	·80 to ·90.	·90 to 1·0.	above 1·0.	No. of Samples.
A. Salinity of Soils under virgin conditions.													
Surface†	55	16	6	3	7	10	3	...	...	...	...	...	31
Subsoil	7	4	...	4	4	22	7	19	11	11	7	4	27
B. Bare patches where no crop or weeds have grown on cultivated land.													
Surface†	14	14	28	5	5	5	5	5	...	...	10	9	21
Subsoil	...	5	...	...	10	15	15	20	10	5	10	10	20
C. Areas where some growth of crop, weeds or grass occurred on cultivated land.													
Surface†	41	36	14	4	5	...	...	...	...	...	...	...	22
Subsoil	...	5	10	24	24	9	9	5	9	...	...	5	21

* Determined by the Wheatstone Bridge method of Davis and Bryan (1910).

† Generally from a surface layer 4 to 6 inches deep.

The analysis of numerous soil samples taken to represent the various soil conditions established a marked correlation between crop failures and soil salinity. Of course, other factors operated in some instances, but the majority of the cases were due to excessive salinity and this developed principally on the heavy "gilgai" soils and the "kopi" types. From examinations made it was evident that only a thin layer, perhaps 6 inches deep, of salt-free surface soil was necessary to grow some sort of a crop but, following clearing, surface concentration of salts, brought up by capillarity, proved serious in these types in later years.

Table 2 gives a picture of the virgin soils of the Salmon Gums district with respect to salinity and, also, the relation between salinity and crop growth.

From this information it is apparent that soil salinity in the Salmon Gums district is very general in the virgin country but under these conditions the surface is usually quite low in salt content. On certain soil types salt concentration in the surface layers occurs after clearing and cultivation, and this concentration, associated with a highly saline subsoil, is responsible for a considerable proportion of crop failures. In this district, some of the crop failures not due to high salinity, are associated with "kopi" soils which have been found generally unsatisfactory for wheat growing in the drier portions of the district irrespective of salt incidence. Soils on which crops, weeds and grass grow are found to exhibit, in general, a much lower salt content than the less satisfactory sites.

Some details of analyses of individual soil samples from sites representing land which carried fair to good crops and that which carried poor or very poor crops are given in Table 3.

TABLE 3.

Analyses of Soils from Sites representing land which carried fair to good wheat crops and poor and very poor crops.

Fair to Good Crops.				Poor and Very Poor Crops.	
Depth.	T.W.S.S.	Depth.	T.W.S.S.	Depth.	T.W.S.S.
inches.	%	inches.	%	inches.	%
0— 3	·04	0— 8	·03	0— 5	·07
12—14	·41	below 12	·26	18—20	1·1
14—20	·46				
		0— 5	·04	0— 4	·05
0— 3	·04	5—12	·22	4—10	·30
6—12	·32	12—24	·38	10—24	·41
12—18	·47				
		0— 6	·13	0— 6	·17
0— 2	·06	6—12	·16	6—12	·37
2—12	·51				
		0— 6	·06	0— 9	·38
0— 4	·07	6—15	·22	9—18	·63
4— 8	·04				
8—24	·66	0— 3	·03	0— 3	·14
		3—18	·47	3—18	·71
		below 18	·59	18—20	·86

Recognising the number of complete failures associated with excessive soil salinity and the generally high level of salinity associated with the poor and very poor crops in comparison with the fair to good crops, there can be no doubt as to the importance of soil salinity in the Salmon Gums district. This finding confirms

that of Professor J. W. Paterson in his evidence to the Royal Commission on the mallee belt and Esperance lands (1917).

The results are of additional value in pointing to the relative importance of surface and subsoil concentrations in relation to crop growth and form the basis for tentative standards to be used in the interpretation of later results. In later investigations soils were classified as highly saline for wheat growing where the surface contained above 0.20 per cent. and the subsoil above 0.40 per cent. total water soluble salts. The surface soil was generally taken to a depth of from 6 to 12 inches and the subsoil below 12 inches deep.

It is concluded that, when due allowance is made for soil variability and the importance of other factors affecting crop growth, this information establishes the fact that the incidence of soil salinity has been the most important single factor of those contributing to the unusually low wheat yields in the Salmon Gums district.

Another very important factor is the occurrence of the unsatisfactory "kopi" soil, and there is every reason to believe that the avoidance of saline and "kopi" soils would have enabled the Salmon Gums district consistently to approach the State average for wheat yield.

The Reconnaissance of the 3,500 Farms Scheme.

Following the diagnosis of the principal factors responsible for the unsatisfactory wheat yields at Salmon Gums, a reconnaissance was made of that portion of the 3,500 Farms Scheme lying south of Southern Cross and between the Rabbit-proof Fence and Salmon Gums.

During the previous three years some 12 parties from the Department of Lands and Surveys had been in the field and had classified and mapped the land on the basis of vegetation and general soil characters into three main classes:—

First class:—Woodland and mallee country in which a good clayey subsoil occurred within a few inches of the surface.

Second class:—Mallee country associated with sandy soils.

Third class:—Heath and wodjil country associated with sandy and gravelly soils—the so-called sandplains.

The information was compiled on base maps coloured according to land class, and, by a process of reduction, the work was represented on a plan using a scale of 300 chains to the inch. This plan affords a general picture of the whole of the area and, at that time, was the finest piece of land classification attempted in Australia. From it the location of the principal blocks of first class agricultural land for wheat growing and sheep raising purposes were accurately known. As it had been decided to organise the settlement principally on the first class land, it was then possible to plan routes for railways and roads and design holdings on the basis of the base maps prepared. Figure 2 shows by means of a sketch, the general distribution of first class lands throughout the area, and points to the difficulties involved in serving an area in which the recognised potential farming land was so widely scattered. It was estimated that only about three farms per mile of railway line could be surveyed if settlement was confined to the first class lands as had been decided.

As the first class had been adopted as the basis for settlement the investigations were confined largely to the woodland soil types and the heavier types of mallee country as mapped by the Lands Department. Some three trips were made through various portions of the area to study both the soil and ecological conditions. In all, the field work occupied about nine weeks and soil samples, representing largely the first class land, were examined from about 550 miles of traverses through the

area. Over 1,500 samples from 650 sites were analysed and the results interpreted in the light of local evidence from the Salmon Gums district supplemented by experience available from other parts of the world.

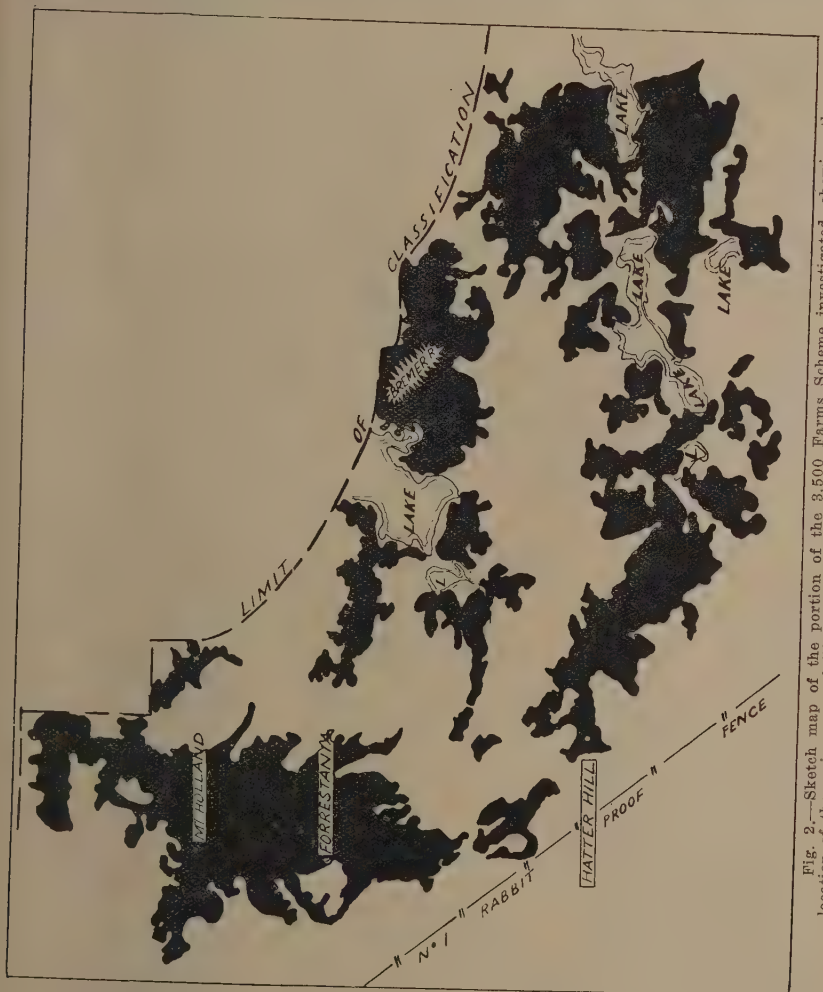


Fig. 2.—Sketch map of the portion of the 3,500 Farms Scheme investigated, showing the location of the main areas of "first class" soils.

a.—GEOLOGY AND PHYSIOGRAPHY.

The area forms part of the dissected Great Plateau of Western Australia.

In common with the bulk of the Western Australian wheat belt, it may be described as a gently rolling, slightly dissected plain, broken at wide intervals by low hills and ranges of basic intrusives and auriferous rocks and, at the Fitzgerald Peaks, by a high granite boss (Peak Charles, 2,100 feet above sea level). The lower portions of the plain are probably ancient valley formations, formed by dissection of the plain, and are generally 800 to 1,000 feet above sea level. The lowest portions of these valleys are commonly occupied by broad salt "lakes" or salinas (see Fig. 2) and at higher levels are the normal woodland soils—the first class soils of

the land classification. The soils of the higher portions of the plain, generally 1,000 to 1,300 feet above sea level, are characteristically sandy and gravelly in nature. They are not related pedologically to the normal woodland soils but are highly leached and acidic in reaction. Furthermore, they support a heath vegetation and are generally regarded as of low agricultural value. Consequently, they are classified as third class and were not considered in the settlement plan. According to Prescott's (1931) theory, which is now well substantiated, these areas represent the remains of an acient highly leached soil which protect the underlying rocks from soil-forming agencies and the production of "normal" soils for this climatic zone.

Intermediate between the valley woodland soil types and the heath soils of the higher parts of the plain, are the mallee types. These do not occupy a large proportion of the area over the main portion of the scheme and are regarded as second class for agricultural purposes.

The principal underlying rocks are the very ancient Precambrians which include both granitic* and basic auriferous types. The former are more extensive but a considerable proportion of the first class land is associated with the low hills and ranges of auriferous country as at Mount Holland, Forrestania, Bremer Range and Hatter Hill. The granitic rocks underlie both woodland soils in the valleys and sandy and gravelly soils of the sandplain or heath country.

While no geological evidence was obtained, the soil characters indicate that there are also areas of Miocene sediments similar to those recognised in the Salmon Gums district.

(b) VEGETATION.

In outward appearance, the vegetation associations resemble those of the settled portions of the Western Australian wheat belt. Areas of eucalyptus woodlands, strips and small blocks of mallee country and expenses of heath country or sandplain are the principal vegetation groups. However, closer examination and recognition of the species of plants comprising the various associations reveal very important differences. In addition to the well known and widely distributed salmon gum (*Eucalyptus salmonophloia*), gimlet (*E. salubris*), morrel (*E. longicornis*), and yorrel (*E. gracilis*), other species of trees of more restricted habitat are merrit (*E. Flocktoniae*), white barked redwood (*E. oleosa* var. *transcontinentalis*), ribbon bark (*E. dumosa*), *E. calycogona, E. annulata* and black morrel (*E. melanoxylon*). A wide variety of mallees are recognised, of which *E. diptera*, and *E. grossa* appear to be confined to the region. Other species of more general distribution are *E. eremophila*, swamp gimlet (*E. spathulata*), *E. annulata, E. oleosa, E. dumosa, E. calycogona, E. leptophylla, E. cylindriflora, E. gracilis. Melaleuca* spp. are very common and often form a dense undergrowth. Various *Eremophila* spp. are represented throughout the area as also is the genus *Acacia*. Saltbushes and greybush (*Cratystylis conocephala*), occur in patches while widely occurring species are *Halgania* spp., *Wilsonia humilis,* daisy (*Olearia Muelleri*), rosemary (*O. revoluta*), cherry (*Exocarpus aphylla*), hops (*Dodonea* spp.), centipede bush (*Templetonia sulcata*), *Daviesia aphylla* and spp., camel bush (*Alyxia buxifolia*), *Boronia xerophila,* quondong (*Santalum acuminatum*), *Grevillea* spp., *Scaevola spinescens,* spinifex (*Triodia* sp.), *Bossiaea leptacantha,* etc. The ecological significance of the vegetation associations is very imperfectly understood, but there is no doubt that soil conditions differ here from other portions of the wheat belt and this fact correlates with the number of distinct vegetation associations characteristic of this

* In the absence of geological surveys acidic crystalline rocks of the area are described as granitic. It seems likely, however, that considerable areas of these granitic rocks are related to the Whitestone series which are metamorphic and that the igneous granites are represented by the bosses which outcrop throughout the area but do not cover a very large area. One of the Fitzgerald Peaks, Peak Charles, with a height of 2,100 feet, and which rises about 1,300 feet sheer out of the plain, is an unusual representative of these granitic bosses.

TABLE 4.

Rainfall Records for Centres representing the portion of the 3,500 Farms Scheme Examined and for Merredin to afford a comparison with other Districts of similar rainfall.

Station	Years Recorded to 1937. inclusive.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Salmon Gums ...	16	54	58	130	112	139	146	131	150	102	107	83	76	1,288
Grass Patch ...	32	42	69	97	89	170	166	156	166	130	131	91	77	1,384
Lake King	8	50	14	180	74	160	151	176	180	94	132	61	49	1,321
Emu Rock* ...	33	43	34	80	82	139	130	141	158	78	69	67	34	1,055
Southern Cross ...	48	48	58	103	84	139	139	139	119	74	64	49	50	1,066
Merredin	34	42	42	99	98	155	200	216	160	107	88	43	55	1,305

* Emu Rock may be taken to represent Lake Carmody and Marble Rock.

(Information supplied by the Commonwealth Meteorologist.)

area. These facts are the basis for the definition of the Fitzgerald soil region by the writer (Teakle 1938).

(c) CLIMATE.

The climate over the bulk of the portion of the 3,500 Farms Scheme examined will closely resemble that of Salmon Gums and Grass Patch and the area will benefit from the influence of the Southern Ocean and a longer growing season. The northern limits of the area, however, are likely to approach Southern Cross conditions climatically and will thus be drier and more hazardous agriculturally from the standpoint of climate.

Rainfall records for Salmon Gums, Grass Patch, Emu Rock (representing Lake Carmody and Marble Rock), Lake King, Merredin and Southern Cross are given in Table 4.

Attention may be drawn to two important characters of the rainfall incidence of these areas—

1. In comparison with the more northern districts represented by Merredin and Southern Cross, the period of generous rainfall (above 100 points per month) extends over a longer period and includes October.
2. The rainfall per wet day is very low but is similar to that for other districts of similar rainfall as shown below:—

Station.	Period	No. of Wet Days.	Rainfall per Wet Day.	Average Annual Rainfall.
			points.	points.
Salmon Gums	1919–1932	76	16·9	1,282
Lake King	1930–1936	81	16·0	1,292
Lake Brown	1915–1936	65	15·8	1,023

The result of the low precipitation per wet day is very restricted leaching which is reflected by lime and salt accumulation in the subsoil, the absence of streams, and a xerophytic vegetation.

The Soils.

The soil conditions of the Fitzgerald region have been briefly described by Teakle (1938), but few details were possible in that paper. The present paper attempts to give a more complete picture of the soils of the main portion of the region which was covered by the reconnaissance.

Primarily, the soils reflect the geological conditions, and soil associations related to the following formations may be recognised:—

1. The sandy and gravelly soils of the lateritic peneplain. These are popularly known as sandplain soils and are of low fertility.
2. The soils of the Miocene sediments.
3. The soils of the Precambrian rocks. The forest soils typical of the Western Australian wheat belt are related to these formations and include the well recognised salmon gum, gimlet and morrel soils.
4. The soils of the basic intrusives and auriferous belts. Heavy textured forest soils form in these hilly areas and carry a more varied range of tree eucalypts than other areas. The high fertility level of these soils must be discounted in low rainfall areas on account of a high water requirement.

As the reconnaissance was designed to determine the incidence of soil salinity in the woodland and better class mallee soils on which agricultural settlement was to be based, attention was practically confined to these types. Furthermore, soil salinity is practically unknown in the sandy and gravelly soils of the sandplains and close investigation of these was, therefore, unwarranted.

It has been established that the woodland and mallee soils (or normal soils) are of the solonised type—that is, sodium and magnesium have accumulated in the clay fraction at the expense of calcium. It seems likely that this is due to age-long treatment with soluble salts from the ocean, brought in by the rainfall, under conditions of very restricted leaching. Furthermore, calcium carbonate accumulation in the subsoil is characteristic. The surface, or A, horizon is typically non-calcareous except in one group associated with morrel timber.

Table 5 gives the analyses of soils from the Fitzgerald Peaks district. These results show the calcium carbonate accumulation in the subsoil. Also, the composition of the replaceable base fraction shows the surface soils to be of the calcium-magnesium type but, in the subsoil, sodium, and, to some extent, magnesium have accumulated at the expense of calcium with the formation of magnesium-sodium or sodium-magnesium clays. The high concentration of water soluble salts in the subsoils is apparent.

The soils of the woodland and mallee areas fall into eight main groups:—

A. Sandy surfaced types with a calcareous, clay subsoil. Considerable areas of this group are related to the Miocene sediments.

B. Sandy loams and loams with a calcareous, clay subsoil of the salmon gum forests which are probably largely related to the Precambrian rocks.

C. Powdery calcareous soils, generally associated with morrel timber. They are typical valley soils but are also associated with basic rocks in some instances.

D. Brown, red brown and red loams and clay loams with a calcareous, clay subsoil associated with the basic intrusive rocks of auriferous areas.

E. Clay loams and clays carrying both salmon gum and gimlet woodland and mallee timber.

F. Sandy soils carrying mallee associations.

G. Low lying sandy soils apparently forming on the sites of old lakes or salinas.

H. Red sandy soils associated with the areas of basic intrusive rocks.

A.—*The sandy-surfaced soil types with a calcareous clay subsoil.*

This group includes a number of soil types which are more or less solonised and which show signs of columnar structure in the surface of the subsoil, apparently due to enhanced leaching promoted by the sandy surface.

The surface, or A. horizon, is typically a structureless sand, brown to grey brown and sometimes red brown on the surface, and more or less bleached in the subsurface. The sand rests abruptly on a sandy clay subsoil, which cements in the upper portion on drying out, and which exhibits a more or less irregular surface suggestive of incipient columnar structure. The upper portion of the subsoil is typically non-calcareous but finely divided calcium carbonate as well as calcareous nodules commonly occur from 18 inches to 2 feet below the surface. This subsoil may be described as of massive structure and commonly is of an olive or drab colour, although brown and red brown coloured types occur.

Analyses show the subsoil clay to be of the magnesium-sodium type apparently in equilibrium with calcium carbonate. Phosphate is generally very low and potash high. Salts have accumulated in the subsoil under virgin conditions but readily leach following clearing (Teakle and Burvill (1938)).

TABLE 5.

Analyses of Soils from the Fitzgerald Peaks District and representative of the portion of the 3,500 Farms Scheme Investigated.

Soil Group.	Serial No.	Depth.	Horizon.	pH.	$CaCO_3$.	T.W.S.S.	Total Exchangeable Bases (m.e./100gm. Soil).	Proportion of Total Bases (Percentage).			
								Ca.	Mg.	K.	Na.
		inches.			%	%					
B*	A135	0— 9	A_1	7·61	·06	·0355	6·08	61	31	3	5
	136	9—11	A_2	6·19	·05	·0335	3·71	22	64	3	11
	137	11—21	B — C	6·58	·09	·0245	17·04	13	51	1	35
B	138	0— 3	A	7·29	·23	·0695	9·46	51	40	4	5
	139	3—15	B	8·42	8·57	·4715	22·03	17	40	8	35
	140	15—30	B — C	8·45	1·43	·3275	15·17	15	39	8	38
C	141	0— 6	A	7·86	1·20	·1215	22·30	64	24	8	4
	142	6—27	B_1	7·91	10·8†	·2985	19·09	36	43	10	11
	143	27—39	B_2	8·15	30·2†	·3215	13·76	18	37	16	29
A	144	0— 9	A	7·38	0·05	·0465	4·32	47	30	3	20
	145	9—21	B_1	8·16	·73	·3670	18·68	8	37	14	41
	146	21—30	B_2	8·16	1·07†	·4265	17·54	7	33	11	49

* Site adjacent to granite outcrop and not typical of the group. An immature soil. † Exclusive of limestone rubble.

(Analyses made in the Government Chemical Laboratory.)

Table 6, page 219, shows the occurrence of water soluble salts in group A.

If the lower limit of the high salinity range be taken as 0.20 per cent. total water soluble salts in the surface foot and 0.40 per cent. in the second foot, 35 per cent. of the sites would fall in the high group. However, the leaching of salts following clearing renders group A safe, as far as salinity is concerned, except in areas of poor drainage where a water table may develop.

Soils of this group are associated with a variety of vegetation types, the first natural subdivision being into woodland and mallee phases. Perhaps the most characteristic is the redwood-ribbon bark woodland, but salmon gum, merrit, and occasionally morrel are common. The mallee phase carries a variety of species including *E. eremophila, E. calycogona, E. dumosa,* and *E. oleosa.*

Various teatrees (*Melaleuca* spp.), *Eremophila* spp., *Acacia* spp., and other shrubs are commonly associated with both woodland and mallee phases.

This group may be regarded as belonging to a fasc* which includes such series as Circle Valley, Scaddan and Pallarup.

It is not of high fertility, but is very economical of moisture and very suitable for farming under low rainfall conditions.

B.—*Sandy loams and loams with a calcareous clay subsoil.*

This group represents the typical salmon gum and salmon gum-gimlet woodlands and typically forms in the valleys and on gentle slopes. Very old alluvial material and the acidic or sub-basic Precambrian rocks are probably the usual parent materials.

The soil is typically a brown to red brown sandy loam to loam, non-calcareous and approximately neutral in reaction, with a clay subsoil of similar but lighter colour. The subsoil is calcareous and the calcium carbonate occurs both finely divided and as concretionary nodules.

As in the other groups solonisation is characteristic. The clays of the surface horizons are of the calcium-magnesium type but the subsoil is of the magnesium-sodium type. (See Table 5.)

Salinity is fairly high and about 50 per cent. of the sites sampled in the virgin state would fall in the high salinity class. As leaching would proceed fairly rapidly following clearing, the salinity problem would not be severe.

Table 6 shows the salinity of the samples examined in this investigation.

While the vegetation is normally predominantly salmon gum or salmon gum and gimlet, other species occur including morrel, merrit and yorrell, and a variety of mallees.

The undergrowth varies considerably but may include centipede bush, salt bush, hop, *Daviesia sp.,* quondong, teatrees and acacias.

This group of soils forms excellent farming land, particularly when the rainfall is generous. Water soluble salts leach fairly readily in these types where the timber has been cleared and the salt problem is not deemed very serious even where the soil was affected by considerable salinity in the virgin state.

C.—*Powdery, calcareous soils, generally associated with morrel timber.*

The soils of this group are representative of the brown, grey brown, and grey snuffy morrel types of the drier wheatbelt and, to some extent, of the "kopi" soils of the Salmon Gums district. They may be regarded as members of the fasc which includes such series as the Beete, Campion, Westonia and Milarup. Perhaps the most characteristic features of these soils are—(a) the snuffy or powdery structure, (b) the occurrence of calcium carbonate on the surface as well as in the subsoil.

* The term fasc is used to denote a group of soil series, usually over a range of districts, which are generally similar in origin and development but between which local differences are sufficient to classify them as distinct series. (Milne, 1935.)

In the area under discussion this group of soils typically carries a woodland of morrel with an undergrowth including such species as boree (*Melaleuca pauperiflora* and *M. quadrifaria*), daisy, *Eremophila* spp., salt bushes (*Atriplex spp.*), various *Acacia* spp., etc. Sometimes merrit predominates, and various mallees may occur as an undergrowth.

While these soils typically occur in the valleys, frequently forming a band between the salmon gum woodland and the lakey country, in some instances they have developed on basic dykes and outcrops associated with auriferous country. It is thought (Teakle, 1938, p. 154) that the nature of the vegetation plays an important part in the surface accumulation of the calcium carbonate. In the first place, the concentration of roots in the surface layers effectively restricts penetration of water, and, in the second place, the leaf and bark fall of these plants may add more calcium to the surface than other types of vegetation.

The typical profile is a surface horizon about 12 inches deep of a brown to grey brown powdery, calcareous sandy loam resting on a brown to fawn clay loam to light clay which is highly calcareous. Small and large nodules of calcium carbonate may occur in the subsoil and sometimes a calcium carbonate pavement is encountered. Red brown and even red types as well as grey types have been included in this group.

The subsoil clays are highly solonised. (See Table 5.) Chemically, plant foods are more generously supplied than in most other groups but the salinity is undesirably high as about 60 per cent. of the sites fall in the high group, Table 6. As leaching is restricted and the capillary properties of this soil are above normal, loss of water soluble salts after clearing is slow and there is a tendency to surface accumulation in the form of bare patches resulting from surface evaporation of moisture drawn from the subsoil by capillarity. Furthermore, these soils appear to be unsuitable for wheat growing in low rainfall areas until compacted by stock and the physical properties become altered by pasture establishment and cropping with very shallow cultivation.

In view of these disabilities, soils of this group, even when not saline, are of low value for wheat production, particularly in the initial stages, and where saline have a low agricultural value.

D.—*Brown, red brown and red loams and clay loams, with a calcareous, clay subsoil, associated with the basic intrusive rocks of auriferous areas.*

Areas of auriferous country, characterised by low hills and ranges and basic intrusive rocks, occur in a number of places of which Mount Holland, Forrestania, Hatter Hill and the Bremer Range are representative. The soils of the basic rocks of these areas are heavy textured and redder in colour than other soil types and carry a more varied range of species in the eucalyptus woodland.

To deal first with the vegetation, it is noteworthy that, in addition to salmon gum, gimlet, morrel and merrit, various blackbutts (including *E. corrugata*) and tree forms of *E. calycogona*, *E. annulata* and *E. dumosa* are common. Besides these, *Melaleuca pauperiflora*, *M. quadrifaria*, grey bush, various *Eremophila* spp. of the Kalgoorlie type, and acacias are important in the vegetation associations.

The soils range from brown to red loams and clay loams and often show a surface sprinkling of blackish, ferruginous gravel. Greenstone pebbles sometimes occur on the surface and are often imbedded in the subsoil clay. The subsoil shows heavy clay accumulation and is typically calcareous. Decomposing basic rock in always encountered at shallow depths.

Little is known of the chemical properties of these soils except that they are generally highly saline (see Table 6), a fact associated with the heavy texture and

restricted leaching. Agriculturally, they would be highly productive under a generous rainfall, but under the conditions prevailing, must be regarded as unsuitable for wheat growing except in abnormally wet years. On account of the heavy texture, improvement in salt status would be slow under light rainfall conditions and after the initial crop or two development for pasturage such as wimmera rye grass and saltbushes over a period of years would be advisable before wheat growing was again attempted.

E.—*Clay loams and clays of the gimlet and salmon gum woodlands and of mallee areas.*

This group of soils resembles those of group D in the property of a heavy texture but are typically valley soils and are not obviously associated with any particular rock type. In colour they show less of the red shades than group D and are generally associated with a gimlet and salmon gum woodland. In the eastern portions of the reconnaissance in the vicinity of the Salmon Gums country, a mallee or stunted eucalypt association often replaces the woodland and the geology is probably different from more western areas.

The soil profile consists typically of a brown or red brown clay loam or clay, resting on a brown or red brown calcareous, clay subsoil of considerable thickness. Crabholes, or gilgais, are common. Soil series of this group would belong to the same fasc as the Kumarl and Dowak series of the Salmon Gums area, the Camm series of the Lakes district and the Welbungin series of the Lake Brown area.

Besides gimlet and salmon gum, merrit and morrel with boree, native cherry, acacias and other plants frequently occur on the woodland association.

The mallee association of the eastern portion includes *E. diptera*, merrit, yorrel and *E. oleosa*, with an undergrowth of melaleucas, acacias, eremophilas, etc.

This group of soils exhibits an undesirable degree of salinity as some 75 per cent. of the samples analysed fall in the highly saline class. In the absence of salinity, these heavy textured soils are very productive when the rainfall is adequate and superphosphate is used. Under low rainfall conditions, however, returns are usually disappointing on account of the high moisture capacity of the soil and restricted penetration of the moisture. Where salinity is unduly high, experience at Salmon Gums indicates the first crop of wheat is usually satisfactory but disappointing returns are obtained subsequently. As wimmera rye grass and trailing saltbush do well on soils of this group, it is good practice to establish these for pasture purposes after the first wheat crop. The preliminary results of experiments at the Salmon Gums Research Station suggest that a period under pasture between wheat crops may contribute materially to the reduction in salinity and, hence, the reclamation of this important group of soils.

F.—*Sandy soils carrying mallee associations.*

Considerable areas of mallee country are associated with sandy soils in which a clayey subsoil, usually more or less calcareous, occurs at depths generally in excess of one foot. These soils belong to the fasc which includes the Doust series of Salmon Gums and are generally of low fertility and subject to wind erosion under cultivation.

The profile consists of a grey, grey brown or yellow brown sand, somewhat bleached in the subsurface, resting on a brown to greenish brown cementy, sandy clay.

Common species in the vegetation associations are *Eucalyptus dumosa, E. eremophila, E. leptophylla* (tree and mallee forms), redwood, broombush, *Grevillea* spp., *Daviesia* spp., *Boronia* sp., centipede bush, and a variety of

psamophilous plants. The salt status is low and is not a factor in the evaluation of this type.

As these soils have been generally classified as second class, they were not considered as an important factor in the land settlement scheme. However, their favourable moisture relations render them of value in the low rainfall areas but they need the use of a system of crop rotation which will raise the fertility level and control soil erosion.

G.—*Low lying sandy soils apparently forming on the sites of old lakes or salinas.*

Extensive areas of sandy surfaced soils occur in depressions and low-lying areas surrounding the salt lakes or salinas. The profile typically consists of a grey to grey brown sand, with a whitish subsurface layer, resting on an olive or greenish calcareous sandy clay subsoil. In many respects, the type resembles certain types of group A but drainage conditions are different, the subsoil may be more highly saline and there is a danger from a rising salt water table following the clearing of the surrounding country. The vegetation always includes certain characteristic plants such as *Melaleuca thuyoides* and swamp gimlet. Redwood, *E. leptophylla* and a variety of melaleucas also occur in some sites.

Experience throughout the settled wheat belt shows the liability of soils of this group to become excessively saline within 10 or 20 years of the development of the higher land and, consequently, it is considered unwise to include them as types of permanent value as arable land. They may be safely used in association with more suitable types because, contrary to popular belief, their development will not promote salt encroachment on more valuable land elsewhere. But it should be realised that in the course of time salinity may render them unprofitable for cultivation.

Fortunately, the area of this group of soils is not large and they have been given only second class value in the Lands Department classification. Consequently, they are of little importance as a factor in the land settlement under consideration.

H.—*Red sandy soils associated with the areas of basic intrusive rocks.*

Associated with the low hills and ranges of basic intrusive rocks are areas of reddish woodland soils which appear distinct from any other group and resemble certain of the goldfields types rather than more coastal soils. They occur principally in the Bremer Range which is included in the Coolgardie soil region rather than in the Fitzgerald region (Teakle 1938).

The woodland is characteristically open and includes salmon gum, gimlet, a large tree form of *E. dumosa*, a tree form of *E. eremophila*, morrels, and merrit. Smaller species include borees, teatrees, eremophilas, spinifex, hop, acacias and a variety of mallees.

The profile features include a fine sandy or sandy loam non-calcareous surface, red or red brown in colour and commonly gravelly, and a red or light red calcareous clay subsoil. Generally clay accumulation occurs at a depth of 6 to 12 inches below the surface and lime at 15 inches.

The soils are characteristically non-saline (Table 6) and, under a suitable rainfall, should be good agricultural land. Unfortunately, they occupy only a very small area and, consequently, do not materially affect the land settlement problems of the area. They are interesting as an exception to the general rule for the areas of salt accumulation in clay subsoils. Perhaps the constitution of the clay fraction of the soils of this group differs from that of the more general soil types.

TABLE 6.

Distribution Table showing the Incidence of Salinity in the Soil Groups described in the 3,500 Farms Scheme Reconnaissance.

Soil Group.	Depth.	Percentage of samples in each range of Total Salt Concentration* expressed as per cent. in dry soil.											Number of Samples.	Percentage of Samples in High Salinity group.
		Up to .05.	.05 to .10.	.10 to .20.	.20 to .30.	.30 to .40.	.40 to .50.	.50 to .60.	.60 to .70.	.70 to .80.	.80 to .90.	.90 to 1.0.	1.0 to 1.1.	
	inches.													
A	0— 6	65	22	9	2	2	...	...	...	...	...	...	...	105	4
	0—12	41	16	21	15	6	1	...	...	...	...	...	...	177	22
	12—24	6	7	11	15	26	16	12	4	2	1	...	...	196	35
B	0—12	30	14	27	14	11	3	1	...	...	...	...	...	119	29
	12—24	4	3	8	15	19	15	20	5	7	4	...	...	117	51
C	0—12	22	14	21	20	9	5	4	1	3	1	...	...	177	43
	12—24	...	2	5	10	21	19	11	8	14	7	1	2	165	62
D	0—12	9	4	8	17	29	17	4	8	4	...	...	...	24	79
	12—24	...	5	...	...	13	4	4	9	26	39	...	...	23	82
E	0—12	10	15	18	17	19	6	7	3	3	2	...	...	93	57
	12—24	2	3	2	9	8	19	11	12	12	18	1	3	91	76
F	0—12	100	...	...	...	...	...	...	...	...	...	...	...	11	nil
	12—24	18	37	27	18	...	...	...	...	...	...	...	...	11	nil
H	0—12	63	19	12	6	...	...	...	...	...	...	...	...	16	6
	12—24	12	13	6	25	19	19	6	...	...	...	...	...	16	25
		Low and moderate salinity.					High salinity.								

* Determined by the Wheatstone Bridge method described by Davis and Bryan (1910).

The Incidence of Soil Salinity.

There is no doubt that the soils of the area examined are closely related to those of other portions of the wheatbelt and could reasonably be expected to respond to agricultural development in a similar way. Experience in the Salmon Gums district pointed to a disturbing factor -soil salinity—which has already been discussed, and the primary purpose of the reconnaissance was to determine the incidence of salinity in the first class soils of the area proposed for settlement.

On account of the importance of soil type in the movement of water soluble salts following clearing (Teakle and Burvill, 1938) the available data with respect to salinity have been considered for the groups of soils described above and are summarised in Table 6.

From this table it is evident that all of the soils in the virgin state, except group F, are characteristically more or less saline and that the heavy textured types of groups C, D and E are generally excessively saline. The lighter textured soils of groups A, B, F and H are less seriously affected and when it is known that leaching following clearing will bring about substantial if not complete reclamation of these types, it is evident that the soil salinity problem is largely confined to soils of groups C, D and E. The importance of this will be considered in the next section, after soil salinity in relation to certain factors has been discussed.

(a) *Soil salinity and vegetation.*

While certain plants such as samphire, and to a less extent, one of the bores (*Melaleuca quadrifaria*) and grey bush (*Cratystylis conocephala*) may be commonly associated with saline soils, it was found that the vegetation, as a general rule, was of little assistance as an indicator of excessive salinity. Apparently, the species of the wheat belt areas have a wide range of salt tolerance and salt is not normally an important factor in determining the plant association which establishes on the normal soil types.

Table 7 shows the incidence of salt in soils on which a number of characteristic species were important in the vegetation association.

The apparent importance of gimlet as an indicator of salinity is due to another factor—the fact that gimlet commonly grows on heavier textured soils in which salt will accumulate on account of restricted leaching.

(b) *Soil salinity and elevation.*

Following on the definition of a soil salinity problem in the area, Dr. Ward, the Government Geologist of South Australia, and Mr. Lockhart Jack of his department, were consulted by the Development and Migration Commission regarding the problem. From a consideration of possible underground water movements and the effects of clearing the higher lands, they suggested that—

1. A relief map would provide the key to the problem of distribution of saline lands;
2. The high lands would be safe and likely to improve.

Further, they recommended that—

1. Traverses be run through several representative sections, and levels taken;
2. Soil salinity and soil profile observations be made along these traverses and plotted to show the safe and dangerous levels.

In effect, this information had already been obtained by means of aneroid levels taken during the course of the reconnaissance and using the railway surveys as bases.

TABLE 7.

Distribution Table showing the Salinity of Soils of the 3,500 Farms Scheme on which various Species formed an important fraction of the vegetation association. The ranges represent Total Water Soluble Salts in the Subsoil (second foot).

Species.	Percentage of total recorded occurrences of the species in each range of total water soluble salt concentration (per cent in oven-dry soil).												Total Recorded Occurrences.
	0·05 and lower.	·05 to ·10.	·10 to ·20.	·20 to ·30.	·30 to ·40.	·40 to ·50.	·50 to ·60.	·60 to ·70.	·70 to ·80.	·80 to ·90.	·90 to 1·0.	above 1·0.	
Salmon Gum	6	4	6	17	17	15	14	8	8	4	1	...	197
Gimlet	2	2	2	7	5	11	14	9	22	22	4	...	55
Morrel*	5	3	8	11	26	13	11	9	9	3	1	1	206
Merrit	1	3	6	8	12	16	11	8	14	11	6	4	141
Redwood	6	1	11	19	24	19	12	3	3	2	...	...	108
Grey bush	...	...	...	20	10	20	10	10	20	...	...	10	10
Boree (*Melaleuca quadrifaria*)	2	2	6	6	10	10	19	8	19	8	9	1	53

* Includes *Eucalyptus longicornis*, *E. melanoxylon* and *E. oleosa*.

TABLE 8.

Distribution Table showing the Salinity of Woodland Soils of the portion of the 3,500 Farms Scheme in relation to elevation above sea-level. The ranges represent Total Water Soluble Salts in the Subsoil (second foot).

Elevation Range. (Feet above sea level)	Percentage of total sites taken in each elevation range falling in each range of total water soluble salt concentration (per cent. in oven-dry soil).											Total Sites in the Elevation Range.
	0·05 and lower.	·05 to ·10.	·10 to ·20.	·20 to ·30.	·30 to ·40.	·40 to ·50.	·50 to ·60.	·60 to ·70.	·70 to ·80.	·80 to ·90.	·90 to 1·0.	above 1·0.	
Below 1,000	8	8	23	8	7	31	15	...	...	...	...	...	13
1,000—1,100	3	3	6	11	14	17	11	3	11	3	12	6	35
1,100—1,200	5	3	7	20	19	13	17	5	3	8	...	...	60
1,200—1,400	5	...	5	9	13	13	9	13	23	5	5	...	22
Above 1,400	...	...	25	25	25	...	25	...	...	...	...	...	4

The relation between elevation and incidence of soil salinity is shown in Table 8.

These results conclusively show that the incidence of soil salinity in the virgin woodland country bears no relationship to elevation. Consequently, a relief map would be valueless as an indicator of safe and dangerous lands.

The soil profile studies leave no doubt that the dominant factor in salt accumulation is the permeability of the soil to moisture. Accepting the rainfall as the source of the water soluble salts, there can be no question that heavy clay soils, and types in which the combination of soil profile and vegetation cover also greatly restrict leaching, will show an accumulation of these salts irrespective of elevation. Subsequent behaviour of the water soluble salts following clearing of the vegetation will be dependent on the permeability of the soils and this is also a direct function of soil type. Teakle and Burvill (1938) have discussed this, and the application of the principle has already been made in the discussion of the various soil groups studied in this area.

Of course, there will be a rise in the water table after clearing and the low lying soils will become affected when the salt water level comes within a few feet of the surface. Soils of Group G are particularly liable to be affected, but micro-relief rather than general relief would be necessary to define these areas. Again, the soil type seems a more satisfactory method of defining such areas liable to be affected by soil salinity in the course of years.

(c) *The composition and source of the water soluble salts.*

The total water soluble salts may be extracted by treating the soil with water. In this work 5 parts of water were used to one part of dry soil and the resulting extract analysed by the usual methods. Analyses show that the dominant constituent is sodium chloride or common salt. The average of analyses representing 77 samples shows sodium chloride to constitute 70.2 per cent. of the total water soluble salt fraction. The proportion may be higher in the more saline samples and becomes lower as the salt content of the soils decreases. Regarded from the aspect of supply of plant nutrients, the analyses indicate that these woodland soils are well supplied with nitrate and with water soluble potassium, calcium and magnesium. Sulphates are high and phosphate appears to be the ingredient most needed for fertiliser purposes.

Table 9 gives the average of analyses reported in Table A of the appendix.

TABLE 9.

Average of Analytical Data representing 77 Samples of Soil from the 3,500 Farms Scheme.

Ion.	ppm Dry Soil.	Ion.	ppm Dry Soil.	Empirical Salt Combination.	ppm Dry Soil.	Per cent. of T.W.S.S.
Cl	1,627	Ca	52	$CaCO_3$ ...	10	·3
HCO_2	307	Mg	55	$Ca(HCO_2)_2$ ...	194	5·1
CO_3	6	K	22	$Mg(HCO_2)_2$ ...	193	5·0
SO_4	490	Na	1,429	$MgSO_4$ ...	115	3·0
NO_3	21	...	...	K_2SO_4 ...	20	·5
				KNO_3	34	·9
Totals	2,451	...	1,558	Na_2SO_4 ...	573	15·0
				NaCl	2,680	70·2
Total Water Soluble Salts in Empirical Combination					3,819	100·0
Excess cation as Sodium					190	...

The composition of the water soluble salt fraction approximates that of the salts of sea water and, as pointed out by Teakle (1937), there is little doubt that they have their origin in sea-water. Further, it is most probable that the sea-water was blown inland as an evaporated spray and later deposited on the soil in the rainwater. Analyses of rainwater collected over a 4-year period on the Salmon Gums Research Station show that about 27 pounds of salt are deposited per acre annually by this avenue and it was calculated that it would take only 37,000 years to account for the amount of salt in the soils of the region, assuming an average depth of 50 feet.

The deposition of salt in the rainwater at the Merredin Research Station was only 16 pounds per acre per annum.

(d) *Relation to soil salinity in other districts.*

It has been contended that, prior to clearing, soils of established wheat areas were just as saline as those of this portion of the 3,500 Farms Scheme. There is no factual basis for this statement.

Of course, soil salinity may be recognised throughout the southern portion of the State, irrespective of rainfall, but in the present agricultural areas this is largely due to the movement of saline ground waters subsequent to the development of the country, and presents a problem not yet affecting the areas of virgin country under discussion. Furthermore, the actual area of arable land at present damaged by this manifestation of salinity is relatively small—probably of the order of magnitude of 5 per cent. of the farming lands of the wheat belt.

All available evidence indicates that the soil salinity problem under investigation is confined largely to an area east of Newdegate and south of Southern Cross where the accession of salt per medium of the rainfall, is high (about 27 pounds per acre per annum) and where, under virgin conditions, the low precipitation per wet day is inadequate for the leaching out of the salts when deposited on the clayey woodland soils.

A body of information on the salinity of woodland soils of the salmon gum, gimlet and morrel types has been obtained from a number of special traverses through representative portions of the wheatbelt. (See Fig. 1.) The information is compiled and represented in the scatter diagram, Fig 3. The analyses in this case are expressed in terms of salt (sodium chloride) and not total water soluble salts used in the rest of the investigation. The lower limit for highly saline soils has been taken as 0.30 per cent. salt (NaCl) in the subsoil (second foot). Each dot represents the analysis of a subsoil sample from a site examined along the traverse and the position is given by the scale. Dots above the 0.30 per cent. salt line thus represent excessively saline samples and those below the line samples of low or moderate salinity.

Examination of the scatter of the dots along the various traverses in Fig. 3 shows—

(a) Fourteen out of 38 sites were highly saline on the Lake King-Marble Rock traverse.

(b) From the Marble Rock-York traverse it is evident that over 50 per cent. of the sites were highly saline between Marble Rock and a point a few miles east of Karlgarin. West of this point normal woodland soils were rarely saline.

(c) Between Marble Rock and Campion a high proportion of saline sites was obtained as far north as Hollcton. North of this district no highly saline sites were sampled until the lake country south of Campion was reached. This area is notoriously saline, a fact which correlates with the information submitted in the scatter diagram.

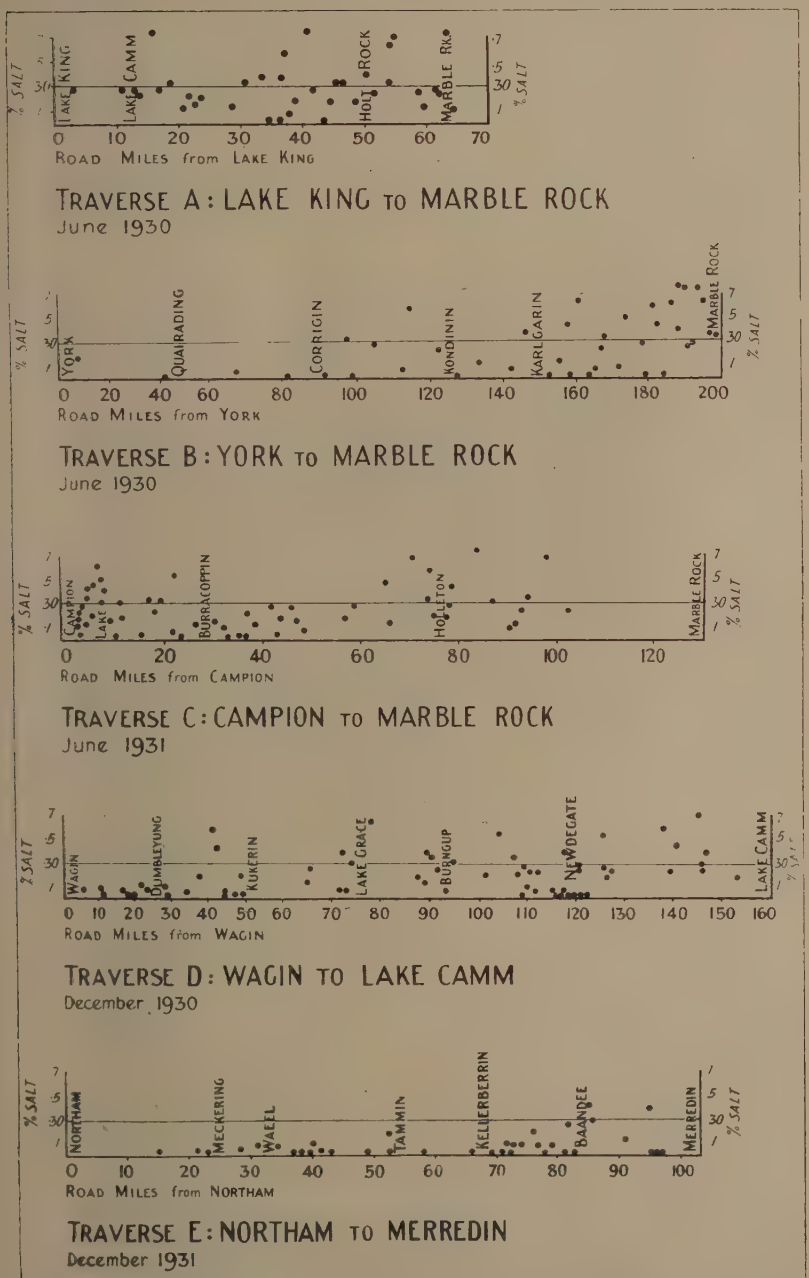


Fig. 3.—Scatter diagram showing the concentration of salt (sodium chloride) in the subsoil (second foot) of woodland soils ("first class") along five traverses representing settled parts of the wheatbelt.

(d) Between Lake Camm and Wagin, soil salinity is relatively uncommon in the normal woodland soils west of Newdegate. A considerable proportion of the samples taken east of Newdegate were saline.

(e) Between Merredin and Northam the normal woodland soils were rarely saline.

Another traverse, made on 29th October, 1930, between Salmon Gums and Coolgardie, established the high incidence of salinity in this low rainfall area. Only two of eight sites fell in the low salinity group and the salt (NaCl) contents of the subsoils (second foot) of the other six sites ranged from 0.41 to 0.82 per cent.

On these traverses, virgin soils were sampled wherever possible but, in the extensively developed areas, samples from cleared land had to be taken in some instances. This affects the mathematical aspects of the situation but does not invalidate the conclusion that the soil salinity problem recognised in the Salmon Gums district and the portion of the 3,500 Farms Scheme investigated is localised and does not extend to a serious degree to the farming areas west of Newdegate and Karlgarin and north of Holleton.

The Significance of the Soil Salinity Problem as it affects the Land of the 3,500 Farms Scheme.

As a result of the reconnaissance survey described, it was concluded in the report of 10th February, 1930, that "The investigations indicate that there is a very serious alkali* problem in the area in question. It must not, however, be regarded as a condemnation of the area." In accordance with the facts presented above, it was pointed out that the heavier soil types (that is, those represented by groups C, D and E) were most seriously affected, and, in an area of limited rainfall, the lighter soil types, which are relatively free of alkali, must be regarded as more suitable for wheat growing.

Ten years of further experience with and close investigation of this problem establish this conclusion and the recent reorganisation of farming operations in the Salmon Gums district has been based on the fact that the lighter soil types in this region are most suitable for safe wheat growing.

The results of subsequent research work have laid a foundation for an estimate of the magnitude of the soil salinity problem in the area covered by the investigation.

At the outset, it must be emphasised that the results of soil analyses for total water soluble salts must be regarded and evaluated for any climatic zone in the light of both soil type and numerous samples.

1. Soil type is of prime importance as it largely determines the behaviour of the water soluble salts after clearing.

2. Large numbers of samples must be taken to represent each soil type so that a statistical treatment of the results may be made.

By this means an estimate of the chances of damage from soil salinity on each soil type is possible, although any single analysis of a soil of unknown type would have little value by itself.

It may reasonably be assumed that the areas of the various types of woodland soils are proportional to the numbers of sites sampled in each group except in the case of group A in which the factor 1.5 should be arbitrarily used as these soils

* Alkali is the old American term which in recent years has been generally replaced by the more appropriate term "salinity."

were purposely sampled less intensively than the others. If this assumption be accepted, the relative areas of the types of woodland soils would be:—

Group	A	196 x 1.5 =	294
„	B	..	119
„	C	..	177
„	D	..	24
„	E	..	93
„	H	..	16
		Total	723

On the basis of the information submitted by Teakle and Burvill (1938) concerning the movement of salt in soils under light rainfall conditions, the percentage of area of soils dangerously saline for wheat growing could be calculated as follows:—

Soil Group.	Number of Saline Sites.	Resistance to Reclamation Factor.	Net Saline Sites after Clearing.
A	69	0	0
B	61	·40	24
C	110	·50	55
D	20	·75	15
E	71	·75	53
Total	... ...	... ...	147

On this reasoning 147 sites would represent 20 per cent. of the total area of woodland soils.

It is admitted that the powdery morrel types of group C are unsatisfactory for wheat growing under low rainfall conditions whether saline or not saline. Therefore, in order to arrive at an estimate of the proportion of woodland soils more or less unsuitable for wheat growing, both on account of salinity and the factor of morrel soils, the remainder of the sites of group C, namely 122, must be added to the "net saline sites after clearing." This brings the proportion of woodland soils more or less unsuitable for wheat growing to 37 per cent.—or about one-third.

As the woodland soils probably occupy from one-quarter to one-third of the total area, this fraction of the "first class" soils represents about 10 per cent. of the total area.

At the present time there is no economic urge for increased wheat and wool production and a policy of consolidation in settled areas is amply justified. However, when the demand arises, there seems no reason from the standpoint of soils why settlement should not spread across the area in question. It is true that certain easily recognisable soil types, constituting about one-third of the total area of woodland soils, would not be suitable for wheat growing, but the other woodland types, together with the better types of light land, should be satisfactory. Furthermore, research work on the saline and morrel or "kopi" soils of the Salmon Gums Research Station indicates that these, while risky for wheat growing, are generally suitable for wimmera rye grass production. This agricultural value as pasture soils could be considered in a reorganised settlement programme which would take advantage of the knowledge of the soil types of the area and the experience gained as a result of many years of farming and agricultural research in the Salmon Gums and other districts.

TABLE A (APPENDIX).

Composition of Total Water Soluble Salts (1 : 5 Water Extract) of Soils of the 3,500 Farms Scheme. Samples represent the surface 24 inches, except where otherwise indicated.

(Results expressed as ppm. oven-dry soil).

ion.	Composite 1—22.	Composite 23—36.	Composite 37—50.	Composite 51—61.	Site 62. Group E. 0—12 inches.	Site 62. Group E. 12—24 inches.	Site 63. Group E. 0—10 inches.	Site 63. Group E. 10—24 inches.	Serial Numbers. Group B. 135. 0—9 inches.	136. 9—11 inches.	137. 11—21 inches.
Cl	2010	1250	1850	1360	4450	4290	2630	3840	115	105	865
CO_3	*nil*	*nil*	*nil*	*nil*	*nil*	*nil*	*nil*	45	*nil*	*nil*	*nil*
HCO_3	390	381	445	442	240	381	373	351	51	45	132
SO_4	609	282	508	432	1029	1523	547	1621	123	82	181
NO_3	13	5	11	8	54	5	7	2	3	4	7
Ca	65	39	93	47	63	50	51	36	35	6	22
Mg	46	28	74	83	127	133	55	96	26	13	20
K	16	26	20	40	20	Tr.	16	26	16	10	Tr.
Na	1860	1220	1786	1401	3305	3630	2062	3356	98	110	1023
NaCl (calc. from Cl) ...	3310	2060	3050	2240	7330	7080	4330	6330	189	173	1425
T.W.S.S.*	4470	2560	4280	3680	9240	9890	5690	8900	355	335	2450
Per cent. as NaCl ...	74	80	71	61	79	72	76	71	53	52	58

* Total water soluble salts.

TABLE A (APPENDIX)—*continued.*

Ion.	Serial Numbers.								
	Group. B.			Group C.			Group A.		
	138.	139.	140.	141.	142.	143.	144.	145.	146.
	0—3 inches.	3—15 inches.	15—30 inches.	0—6 inches.	6—27 inches.	27—39 inches.	0—9 inches.	9—21 inches.	21—30 inches.
Cl	110	1810	1180	160	1170	1580	105	1665	1990
CO_3	*nil*	*nil*	51	*nil*	*nil*	*nil*	*nil*	*nil*	*nil*
HCO_3	258	570	363	318	318	264	87	336	387
SO_4	181	1037	502	74	132	255	49	214	428
NO_3	44	34	35	23	38	88	7	17	6
Ca	50	43	14	155	140	45	13	52	16
Mg	25	35	24	69	96	44	13	46	39
K	45	24	5	16	45	29	10	31	38
Na	199	1686	1275	149	765	1229	149	1562	1723
NaCl (calc. from Cl)	181	2980	1940	257	1930	2550	173	2745	3280
T.W.S.S.*	695	4715	3275	1215	2985	3215	465	3670	4265
Per cent. as NaCl	26	63	59	21	65	79	37	75	77

* Total water soluble salts. Analyses made in Government Chemical Laboratory.

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References.

Davis, R. O. E., and Bryan, H.
1910. The electrical bridge for the determination of soluble salts in soils. U.S.D.A., Bur. Soils Bul. 61.

Milne, G.
1935. Some suggested units of classification and mapping, particularly for East African soils. Soil Research 4: 183-198.

Paterson, J. W.
1917. Report on the occurrence of soluble salts in the lands of the Esperance district. Report of Royal Commission on the mallee belt and Esperance Lands. Government Printer Perth, Western Australia, pp. 167-176.

Prescott, J. A.
1931. The soils of Australia in relation to vegetation and climate. C.S.I.R. (Aust.), Bul. 52.

Teakle, L. J. H.
1937. The salt (sodium chloride) content of rain water. Jour. Agric., West. Aust., 14: 115-123.

Teakle, L. J. H.
1938. A regional classification of the soils of Western Australia. Jour. Roy. Soc., West. Aust., 24 : 123-195.

Teakle, L. J. H., and Burvill, G. H.
1938. The movement of soluble salts in soils under light rainfall conditions. Jour. Agric., West. Aust., 15: 218-245.

PASTURE COMPETITION, DONNYBROOK.

M. CULLITY, Senior Agricultural Adviser.

The Donnybrook Dairy Farmers' Association inaugurated a pasture competition early in 1932, which continued until 1936, when the final awards were made. Owing to the very satisfactory outcome of that competition, it was decided to continue this work on a different basis of judging. In the original scheme of judging, consideration was given to bulk, permanency of the sward, its food value, the value of the plot as an experiment or demonstration, and the cultural treatment, thus introducing many factors, the comparative value of which were difficult to assess. Further, because of the influence of plants previously existing in the pastures, it did not necessarily follow that the most meritorious and informative result would gain the award. However, the competition was finally won with a very fine pasture of subterranean clover and perennial rye grass.

In order to overcome the difficulties that were present in the original competition, and having regard to the trend in pasture improvement work in this State,

it was suggested that, in a further competition to commence in 1937, the award would be given to that farmer most successful in establishing a new species of grass in his pasture.

In order to emphasise the necessity of sowing grass seeds on a thoroughly prepared seed bed, a separate competition was arranged for this work. The scale of points adopted for judging this was as follows:—

Fineness and freedom from clods ..	40 points
Freedom from weeds	30 points
Consolidation	30 points
Total	100 points.

Judging of the plots was carried out during the period June to September and the results are as indicated in the following table:—

Name.	Fineness and Freedom from Clods.	Freedom from Weeds.	Consolidation.	Total.
Maximum Points	40	30	30	100
Brockman, R. T. D. ...	37	29	26	92
Patroni, H.	37	26	28	91
Cunningham, C. J. ...	36	29	25	90
Fry Brothers	34	29	26	89
Sears, W. J.	38	23	27	88
Sharp, C. P.	34	29	25	88
Clifford, J.	35	27	25	87
Forrest, J. R.	37	23	26	86
Trigwell, T. T. (2)	34	23	26	83
Mitchell, V. C.	32	20	25	77
Martin Brothers	34	20	23	77
Egan, J.	30	23	23	76
Hearman, J.	34	15	26	75
Trigwell, T. T. (1)	31	20	23	74
Jones, A.	30	20	20	70

The following points of interest were evident during judging:—

1. All competitors endeavoured to procure a fine seed bed.
2. The use of a tyne cultivator, followed by a rolling, resulted in the breaking of the clods.
3. Rolling to consolidate the soil was carried out on most plots.
4. Sowings were delayed to facilitate weed destruction.
5. The seed was covered in only a few cases, rolling being generally relied on to press the seed into the ground.

Judging of the resultant pasture was carried out in inspections in May and October, 1938. Points were awarded according to the following scale, which is self-explanatory:—

Uniformity and density of sole	30 points
Colour and vigour	30 points
Percentage of new species established ..	40 points
Total	100 points

The results to date are as shown in the accompanying table.

Name.	Uniformity and Density of Sole.	Colour and Vigour.	Percentage New Growth.	Total.	Grand Total.
Maximum Points	30	30	40	100	200
Brockman, R. T.—					
May	22	25	30	77	...
October	22	25	32	79	156
Jones, A.—					
May	18	30	20	68	...
October	24	27	31	82	150
Cunningham, C. J.—					
May	24	23	30	77	...
October	20	18	30	68	145
Fry Brothers—					
May	20	27	19	66	...
October	20	27	31	78	144
Clifford, J.—					
May	23	25	18	66	...
October	22	24	29	75	141
Sears, W. J.—					
May	12	15	15	42	...
October	21	24	31	76	118
Forrest, J. R.—					
May	12	24	20	56	...
October	18	18	25	61	117
Egan, J.—					
May	26	25	10	61	...
October	21	20	15	56	117
Trigwell, T. T.—					
May	20	20	12	52	...
October	18	20	15	53	105
Patroni, H.—					
May	5	5	5	15	...
October	21	22	12	55	70

In all, 15 plots were entered, but owing to various causes only 10 are now receiving attention. Reference to the failures will be made later. Eight plots were sown with *Phalaris tuberosa*, three with a mixture of *Phalaris* and perennial rye grass, two with kikuyu grass, one with perennial rye grass, and one with clovers. This latter did not comply with the intention of the competition, as only plants which can be easily established were used. Of those still in the competition, six are *Phalaris* plots, one kikuyu, two *Phalaris* and rye grass, and one rye grass.

The following comments are offered with reference to points arising from the competition.

Phalaris tuberosa.

The only plots sown with this species which failed, were those sown on scarified pasture, and on land which had just previously carried a crop of potatoes. In the first case, the difficulty of getting the seedlings established against the severe competition of the existing pasture plants was apparently too great, while the deep cultivation required for planting and digging potatoes would not leave the top soil in a sufficiently sweet condition for this plant, and a very poor result was obtained.

In each of the other plots, good results were the rule. Well prepared seed beds were used, and, after an excellent germination, strong healthy plants grew.

The rate of seeding varied from 2 to 6 lbs. per acre, the lower rates giving equally as good results as the heavier. South Australian certified seed was used on all plots.

Superphosphate was the only fertiliser, the average dressing being one bag per acre. Sowing with one exception was carried out broadcast, the seed being usually pressed into the soil with a roller. In one or two cases a drag harrow was used to cover the seed before rolling.

In Mr. C. J. Cunningham's plot, the seed was drilled in about 1 to 1½ inches below the surface, and the impression was gained from an early inspection that the sowing would be a total failure. However, the reverse proved to be the case. An excellent germination resulted, giving almost a full cover of plants in the first season. Sowing was carried out in three sections at the rates of 4, 5 and 6 lbs. of seed per acre respectively. The germination was so good that the 4 lbs. per acre section proved much too thick. As the year went on, however, owing to a slight waterlogging of portion of the paddock, a number of plants died. As a consequence, at the end of the season, the plot was not so good as was early promised. In the autumn of 1938, subterranean clover burr was sown over the paddock, giving a good mixture of *Phalaris* and clover.

In contrast to this, the plot sown by Messrs. Fry Brothers, on the top of one of the highest hills in the vicinity, where drainage is of course efficient, has improved consistently throughout the year. Sowings of 2 and 3 lbs. of seed per acre have proved ample.

Mr. J. Clifford's entry was situated on the flat land adjacent to Thomson's Brook, and although partly flooded on occasion during the winter, was sufficiently well drained to allow excellent growth.

The winning entry for the year was that of Mr. R. T. D. Brockman. This was sown on much lighter land than that used by the other competitors. The seed bed was thoroughly prepared, and sowing was carried out broadcast at the rate of 4 lbs. of seed per acre. A brush harrowing was used to cover the seed. Although the plot was reasonably even over much the greater area, some plants failed to survive in one small portion which appeared much looser and dryer than the remainder. Those plants, even in this patch, which survived the delicate seedling stage, later developed into healthy plants. The size of the plants was generally very satisfactory, particularly where existing in association with subterranean clover.

The plants sown by Messrs. T. T. Trigwell, J. R. Forrest and W. J. Sears also demonstrated that this plant could be successfully introduced into land which had previously grown subterranean clover.

In passing, reference must be made again at this point, to the plot sown by Mr. C. J. Cunningham. This plot, though it had been partially cleared for a number of years, had never carried pasture until the *Phalaris tuberosa* was sown. The success with which the plants are growing, particularly on the higher portion of the paddock, raises the question whether an old pasture site is necessary for the establishment of this species.

Phalaris tuberosa and perennial rye grass.

Mr. W. J. Sears used a mixture of 3⅓ lbs. of *Phalaris tuberosa*, 6⅔ lbs. of Clunes strain perennial rye grass, and 3⅓ lbs. of giant cow grass per acre. This plot carried a heavy cover of capeweed, which mitigated against a rapid establish-

ment of the new sown grasses. However the rye grass succeeded in getting established while the *Phalaris tuberosa* had not made such good progress. This appears to be developing along similar lines to Mr. H. Patroni's plot reported in a previous competition, and supports the conclusion previously expressed that competition in the seedling stage is a serious obstacle to this species. The competition from the rye grass was sufficient to retard its establishment.

Other plots sown in this way were those of Mr. T. T. Trigwell. All these have not been as impressive as when *Phalaris* was sown alone. The rye grass also has not been as successful as was expected. This probably was due to the severe competition from annual plants as previously referred to.

Perennial rye grass.

Only one competitor used this species, and for some reason the result has not been very satisfactory. Seed reputed to be "Colac" strain was used, but there does not appear to be any guarantee that the seed was from good pasture. The early inspections of this plot showed that very little rye grass had been established.

Kikuyu.

Two plots of kikuyu were entered. One has proved a great success, while the other was a total failure. It is believed, however, that this failure cannot be attributed to any weakness of the plant, but rather to the system of management.

Mr. A. Jones planted two paddocks of this grass, one of which planted by the rougher method to be described was for the competition. The paddock was ploughed, cultivated, and worked to a fine surface before the cuttings were dibbled in, 3 feet apart each way. The other paddock was ploughed only, and the kikuyu cuttings planted three feet apart in every third furrow. No other cultivation was carried out on this plot which was the one entered for competition. At the time of the inspection in October these paddocks had almost a full cover of kikuyu.

The other plot which was entered by another farmer was dibbled in under an oat crop. At the time of the inspections in 1938, no kikuyu was seen. All of these plots were high on hillsides away from low lying land which might assist in providing summer moisture.

The difference in the plots has been attributed solely to management. The plot which failed was grazed before the cuttings had developed into plants with a tenacious hold on the ground, with the result that all the plants were torn out by the cattle. The plot which proved successful was not grazed until at least 12 months after planting. In effect, Mr. Jones forgot he had those paddocks on his farm. The result is that he now has several acres of completely matted kikuyu pasture which will prove useful to him in the coming seasons. Twenty acres have been established, or are in the process of being established.

The fertiliser used on these plots has been principally superphosphate at an average dressing of 1 bag per acre. A little "K" type orchard manure was used along a strip in the paddock, but has given no additional result.

The loss of grazing from these plots while they were shut up was very little more than would be experienced by sowing *Phalaris tuberosa* or perennial rye grass on a seed bed prepared after the autumn germination of clover and annual grasses had taken place.

Some lessons which may be drawn from the results to date are as follows:—

1. The preparation of a good firm seed bed is warranted in establishing perennial rye grass and *Phalaris tuberosa* in order to protect them from harmful competition. This is in the absence of a demonstration of more simple methods of establishment.

2. Good seed is necessary. South Australian certified *Phalaris tuberosa* and Clunes strain perennial rye grass have been used with success.

3. Generally, better coloured and stronger plants of these species were seen when in association with clover.

4. Deeper planting with *Phalaris tuberosa*, than that ordinarily recommended, may be used with success.

5. *Phalaris tuberosa* will suit a variety of soils and sites, but does not flourish in wet situations. Good drainage is essential.

6. Perennial rye grass is suited to the flats and lower slopes.

7. Kikuyu can be established in one season, with cuttings planted three feet apart each way, providing no grazing is allowed for that period.

8. Fertiliser applications of 1 bag of superphosphate per acre have been successful in establishing the above species.

9. Rates of sowing of 2 lbs. of *Phalaris tuberosa* and 6 lbs. of perennial rye grass have been shown to be ample, providing good seed is sown on thoroughly prepared seed beds.

10. The introduction of clover where not re-establishing itself in a *Phalaris* or rye grass paddock is advisable.

Suggestions.

The following suggestions are made for the coming season, being based on experiences of the past two seasons on those trial plots, and on other pastures in this and in other districts.

1. A longer rest from grazing would be an advantage. Some of the plots have been grazed almost continuously, and naturally this affects the depth and strength of the rooting system. Allowing the plant to make more top growth will result in (a) a greater bulk for grazing, (b) a greater reserve of plant food being built up in the root system, and so (c) allows a more rapid response after grazing. For this purpose it is suggested that the paddocks be grazed not more frequently than once in 6 weeks, but preferably not more frequently than once in 8 or 9 weeks.

2. In establishing *Phalaris tuberosa* the following methods are worthy of trial. (a) Sowing in the early autumn, on to the damp layer of fallow, prepared in the previous spring. This should result in early germination of the *Phalaris* and its establishment beyond the delicate seedling stage before germination of the annual species present can result in smothering competition. (b) Sowing on the "burn," that is, into the seedbed formed by ashes after a fire. Several small patches of *Phalaris* have been inspected which have been sown into the ashes of burnt logs and hay stacks.

3. Eastern States experience has followed closely that in this State, where perennial rye grass has been sown on to a pasture which has been scarified. The competition from the annual pasture types has been too severe to allow the new plants to thrive. Hence the necessity for destroying this competition by preparing a firm seed bed and, in doing so, retarding the development of the annuals. Further Eastern States experience has showed to advantage, another more simple method which has the advantage of not destroying the grazing in a paddock for any period, in contrast to the full seed bed method, where the paddock is practically of little use for one year at least. In the method referred to above, the seed is sown through the drill with the discs or hoes penetrating the moist soil to a depth of 1 to 1½ inches. The work should be carried out when the soil is only sufficiently moist to scatter freely from the discs carrying with it any seeds which may have been present. This results in a series of drills through the paddock, where no annual seeds are present. The rye grass seed is deposited here and is able to ger-

minate and reach several inches in height before the annual plants can reach across and smother them. Once they are past the first two or three inches, the competition from other plants will not do much damage.

The competition will conclude with two inspections carried out during 1939, one in May and the second in October.

THE IMPERIAL BUREAU OF DAIRY SCIENCE.

In 1936 the British Commonwealth Scientific Conference which met in London to consider the working of the organisations controlled by the Executive Council of the Imperial Agricultural Bureaux, recommended that a new Imperial Bureau of Dairy Science be established. The conference also suggested the National Institute for Research in Dairying as the most suitable location for the Bureau.

Following agreement by all the authorities concerned, the new Imperial Bureau of Dairy Science has now been established at Shinfield, near Reading. Prof. H. D. Kay, O.B.E., Ph.D., D.Sc., Director of the National Institute for Research in Dairying, has been appointed Director of the Bureau. Mr. W. G. Sutton, M.Sc., A.I.C., from Massey Agricultural College, New Zealand, has been appointed Deputy Director and has now taken up his duties. The Bureau is financed co-operatively by the Governments of the British Empire in the same way as the other Imperial Agricultural Bureaux.

The functions of the Bureau are to index research work in dairy science, whether carried out in the Empire or elsewhere; to collect, abstract and collate information bearing on dairy science and to distribute such information both by publication and by private communication to research workers, officials, and advisory officers throughout the Empire. In addition, the Bureau is charged with the duty of establishing and maintaining contact between research workers with common interests, promoting conferences of workers and visits to research centres, and in general encouraging the circulation of information, ideas, material and personnel.

The field of dairy science to be covered by the Bureau was defined by the Conference when recommending its establishment. This field includes the microbiology, chemistry, and physics of milk and its products; animal diseases in so far as they affect milk and its products; the technology of processing milk and manufacturing dairy products; the physiology of milk secretion as affecting quality and quantity of milk and dairy products; standards for the composition and quality of milk and its products.

The routine duties of the Bureau, such as indexing and abstracting, will already be familiar to many dairy workers from the activities of the Bureaux already established in other subjects. An aspect of Bureau work which may not be so well known and understood is the more informal service which can be given to research workers, teachers, and field officers. The Bureau aims to be the friend of these dairy workers. The Bureau will deal directly with the individual workers in dairy science, who are invited to write to the Bureau for information which is not obtainable in their own countries. The Bureau may be able to supply the information itself, or to put the inquirer in touch with someone who can do so more effectively.

The new Imperial Bureau of Dairy Science has been established in answer to requests for a clearing house for information in dairy science; its value to dairy science, and to the dairy industry generally, will largely depend on the extent to which research workers and others avail themselves of its services.

TOBACCO GROWING IN WESTERN AUSTRALIA.

A. SHARP,
Tobacco Adviser.

The history of tobacco cultivation in Western Australia on a commercial scale dates only from about 1930. Prior to that date attempts to produce marketable leaf had been made, but the small areas planted could be regarded as being more or less of an experimental nature. During the 1930-31 season 25 acres were cropped for a yield of 12,500 lbs. of cured leaf. From then on the area planted steadily increased until in 1937-38 an area of 1,215 acres was cropped for a total yield of 854,000 lbs. Coincident with the increase in production, the quality of the leaf has steadily improved until it is now recognised as being second only to North Queensland leaf. Over the last few years the State yield has averaged approximately 700 lbs. per acre of cured leaf and individual crops have frequently yielded 1,000 lbs. per acre and over—figures which compare very favourably with other tobacco-producing districts in the Commonwealth.

The industry is located almost entirely in the Manjimup district in the lower South-West of the State. Various attempts to produce leaf of acceptable type in other districts have so far met with indifferent success.

Climate.

It is generally recognised that a suitable climate is the first essential for the production of good tobacco. The ideal conditions for the growth and proper maturing of the tobacco plant are abundant and evenly distributed rainfall, high temperatures, high humidity, a fair amount of cloudy weather, and absence of hot, drying winds. Climatic conditions at Manjimup differ considerably from this ideal. While the average annual rainfall of 42 inches is about equal to that of the tobacco-growing areas of America, it is not evenly distributed, only about 5 to 6 inches being usually recorded during the five months October to February, inclusive. The months of December, January and February, during which the tobacco crop is maturing and being harvested at Manjimup, are usually characterised by very dry, hot, sunny weather, low atmospheric humidity, and absence of cloud. In addition, hot dry winds during the day and sharp falls of temperature at night are occasionally experienced. It will thus be seen that the West Australian tobacco grower has to contend with weather conditions which are by no means ideal, and if he is to produce the type of leaf demanded by the manufacturers he must take great care that the location of his crop and his cultural practices are such as to offset as far as possible the effect of the rather harsh summer weather usually experienced.

Soils.

The second factor, which is recognised as playing an extremely important part in the production of good quality tobacco is soil of the right type. Generally speaking, the bright flue-cured tobacco of mild, sweet-smoking quality which is in greatest demand to-day can be grown best in light sandy or sandy loam soils of comparatively low fertility. There are quite large areas of soil answering this description in the Manjimup district, and where such soils occur in well-sheltered valleys in association with a clayey subsoil at about 18 to 30 inches depth, they appear to be able to retain sufficient moisture throughout the dry summer months to bring excellent crops of tobacco to maturity without the aid

of irrigation. With the exception of one or two favoured areas, crops grown on hillside land usually suffer considerably from drought, do not mature normally, and yield only a small proportion of bright leaf. Intending growers would be well advised to exercise the greatest care in the selection of suitable areas for tobacco culture. It will usually be found that only a comparatively small proportion of the total area of any particular farm is suitable for this crop.

The Tobacco Plant.

The tobacco plant of commerce (Nicotiana tabacum) belongs to the Natural Order Solanaceae, to which also belong the tomato and potato. It is an annual plant and is propagated in seed-beds and set out in the field when about four inches high. It is a summer-growing plant, being usually planted out in October and harvested during January and February. On harvesting, the leaf is subjected to a curing process, during which a large proportion of the natural moisture is extracted. A number of different methods of curing are in use in various countries, and each method produces tobacco of distinctive type and smoking characteristics. By far the largest demand in Australia at the present time is for leaf of bright colour, fine texture and of mild smoking quality, suitable for cigarette and fine cut tobaccos. This type of leaf is obtained from certain varieties which are suitable for flue-curing. Practically the whole of the tobacco produced in Australia at the present time is flue-cured.

Selection and Preparation of Tobacco Land.

As already explained, the careful selection of land for tobacco growing is extremely important. The present state of our knowledge is insufficient to allow us to say definitely whether any particular area will produce good tobacco or not without actual trial, but a few points may be mentioned as a rough guide. The soil should be a free working sandy loam, either grey, brown, or red-brown in colour. Black sand or peaty soil should be avoided. The greatest essential is that it should be capable of retaining moisture throughout the summer. Previous knowledge on this point is of great assistance in selecting land, but if this is lacking the nature of the subsoil is a fairly reliable guide. A yellow or brown mottled clay or clay loam at a depth of 18 inches to 2 feet can generally be taken as a good sign. Many good tobacco soils contain a proportion of gravel, but very gravelly soils should be regarded with suspicion. The most suitable soils are usually found on gentle slopes and flats between the heavily timbered ridges which are a prominent feature of the local topography. Where the native vegetation, which consists of karri or jarrah in association with redgum (marri), has been allowed to remain untouched on the ridges, protection from wind is afforded. Generally speaking, newly cleared land of suitable type yields very satisfactory crops, both as regards quantity and quality. Land which has been under clover pasture for a number of years, however, usually gives very poor results. The accumulated fertility of such soil, particularly the large amount of organic nitrogen stored by the clover roots, has a disastrous effect on the quality of the tobacco and may render the leaf practically uncurable. Where it is desired to utilise old clover land for tobacco, a non-leguminous crop such as oats, turnips or maize should first be grown in order to remove the excess nitrogen.

The heavy winter rainfall experienced at Manjimup causes a good deal of waterlogging of the valley soils. Where the excess water does not drain off fairly rapidly with the advent of finer weather in the early spring, the necessity for artificial drainage is indicated. Tobacco will not do well on badly drained land, and the leaf produced is of poor burning quality.

Preparation of the land for tobacco should begin in the autumn. It should be ploughed deeply in April or May as soon as the autumn rains have moistened it sufficiently and germinated any weed seeds that may be present. Surface drainage will be assisted where necessary by ploughing in fairly narrow lands and leaving a fairly deep finishing furrow between each land. Where it is not considered necessary to grow a green manure crop, the ground may be left without further cultivation until the following August, when it is again ploughed and cultivated until a fine tilth is obtained. The benefits to be obtained from autumn ploughing are very considerable, but they are not fully realised by many tobacco growers. In the case of newly cleared land, the turning over of the soil exposes it to the sweetening action of sun, wind and rain, while on old land weeds and overwintering insect pests are effectively checked by winter fallow.

Green Manuring.

The soils of the Manjimup district are naturally poor in humus. This is a distinct disadvantage, inasmuch as the tobacco plant grows best in a soil in which there is a good supply of decayed vegetable matter. Fortunately, it is within the power of the farmer to rectify this deficiency by growing and ploughing in suitable green manure crops. Such crops may be divided broadly into two classes, viz., leguminous, such as field peas and lupins, and non-leguminous, such as oats and rye. The former, owing to the property they possess of supporting colonies of nitrogen-fixing bacteria in nodules on their roots (provided the requisite bacteria are either present in the soil or are introduced thereto with the seed itself by natural or artificial means), not only enrich the soil in humus when ploughed in, but add materially to the supply of nitrogen. Non-leguminous crops, on the other hand, are quite incapable of adding fresh nitrogen to the soil.

As already mentioned, it is undesirable to have tobacco soils too rich in nitrogen, therefore the growing of wholly leguminous crops for green manuring is not recommended. Excellent crops of tobacco have, however, been grown after mixed crops, such as oats, or rye, together with field peas, have been ploughed in. In the past, large areas at Manjimup have been successfully cropped annually with tobacco for a number of years, the soil being kept in good condition by growing green manure crops during the autumn and winter and ploughing them under in the early spring. While it is recognised that such continuous cropping is open to serious objection, principally from the point of view of disease and insect pest control, and hence cannot be pursued indefinitely, yet the results already obtained from this system have demonstrated the great benefits to be obtained from the practice of green manuring.

Varieties.

A large number of varieties have been tested in the Department's field experiments at Manjimup during the last five years. The results obtained from these, together with the experience of commercial growers, indicate that the following varieties are capable of producing good crops of excellent quality leaf in this State.

"Hickory Pryor."—This has been regarded as the standard variety for a number of years. It is a good yielder of very good quality leaf where grown under really good conditions, but in some situations it tends to produce a rather coarse leaf, somewhat narrow in proportion to its length, particularly at the top of the plant, and is rather difficult to cure a really bright colour.

"Cash."—This variety is very similar to "Hickory Pryor" in appearance, though of slightly taller habit. Over a period of five years it has yielded slightly

heavier crops than the latter in the Departmental experiments. It is comparatively easy to cure and generally yields a high proportion of bright leaf.

"Kelly."—This variety was imported from New South Wales by the Department for experimental purposes three years ago. It proved an immediate success and is already threatening to oust "Hickory Pryor" from its position as favourite with growers. It prefers the moister types of soil and on these it produces a heavy crop of high quality leaf. The leaf is broader in proportion to its length than either "Hickory Pryor" or "Cash," and is easy to cure.

Leaf of these three varieties is acceptable to Eastern States manufacturers.

"Sport."—This variety was evolved at Manjimup some years ago by Mr. H. J. Limmer, Plantation Manager to Michelides, Ltd., of Perth. It has proved itself remarkably well adapted to local conditions and yields consistently heavy crops of bright leaf. It requires less suckering in the field than most other varieties and is easy to cure. It would be extremely popular with growers were it not for the fact that the smoking quality of the leaf is not altogether acceptable to Eastern States manufacturers, who state that they are not prepared to purchase it in large quantities. In view of this fact, growers who intend producing for the Eastern States market are recommended not to plant this variety.

Several other varieties tested by the Department gave very promising results during the 1938-39 season. These include "Gold Dollar," "Yellow Mammoth," and "White Mammoth." It is inadvisable to accept the results of only one season as conclusive, however, and growers are recommended to plant only the better-known varieties until the newer ones have undergone further trial.

(To be continued.)

LUCERNE COMPETITION.

M. CULLITY, Senior Agricultural Adviser.

In conjunction with the Pasture Competition, the Donnybrook Dairy Farmers' Association conducted a lucerne competition, which was sponsored at the suggestion of Messrs. Dempster and W. E. Hearman. As with the pasture competition, this was divided into two sections, one dealing with the preparation of the seed bed, and the other with cultural operations and growth.

The seed bed inspection resulted as follows:—

Name of Farmer.	Fineness and Freedom from Clods.	Freedom from Weeds.	Consolidation.	Total
Maximum Points	40	30	30	100
Frost, A. C.	40	24	28	92
Langridge, B.	38	26	27	91
Cunningham, C. J. ...	38	25	27	90
Brockman, R. T. D. ...	35	29	25	89
Hearman, J.	36	27	25	88

Inspections of the plots were carried out when inspecting pastures, and the points allotted for 1938 are as follows:—

Name of Farmer.	Evenness, Vigour, etc.	Weeds, etc.	Insects and Disease.	Bulk.	Total.	Grand Total.
Maximum Points ...	30	20	10	40	100	200
Brockman, R. T. D.—						
May	18	8	10	30	66	...
October	15	13	7	36	71	137
Frost, A. C.—						
May	22	7	10	25	64	...
October	18	10	7	35	70	134
Langridge, B.—						
May	20	10	10	20	60	...
October	16	12	9	28	65	125
Cunningham, C. J.—						
May	14	7	10	18	49	...
October	8	10	9	25	52	101

Unfortunately we must record that the conditions as seen during the inspection in October indicate that only two of the plots will be successful. Reasons for this are as follows:—

Plot 1.—Seedlings were destroyed by red mite attacks.

Plot 2.—Competition from couch grass has prevented the plants from obtaining good development, and next year's growth will be reduced.

Plot 3.—Was quite successful in establishment, but rabbit attacks are gradually reducing the number of plants. These pests eat the crown of the roots, and so totally destroy the plants.

The two leading plots, however, do indicate what a valuable plant lucerne can be under conditions which cannot be described as the optimum. The particulars of the plots are as follows:—

Brockman, R. T. D.

The soil is a sandy loam situated on the slope above the Preston river, and carried originally a mixture of jarrah and redgum. A crop of potatoes was taken off the land in the spring of 1936. The land was ploughed during the succeeding summer, and sown with rape which was grazed off during the autumn and winter. The land was again ploughed and harrowed in August, and the operations repeated. The seed and manure were drilled in as shallow as possible, after rolling, and finally a stroke of the harrows was given. Seed was sown at the rate of 6 lbs. per acre. Inoculation of the seed with bacteria was carried out; one bag of super per acre was applied. Harrowing was again carried out when the plants were 3 inches high, and once again during the summer months in order to check weed growth and retain a mulch. After the first rains in the autumn the paddocks were cross cultivated (using a springtyne) to a depth of 2 to 3 inches. A further application of one bag of super was made. The attacks of rabbits were responsible for the destruction of a number of the plants, but reseeding of the bare patches rectified this. The lucerne plants appeared very healthy, and weeds were very few, apart from some bracken. Later in the spring weed attack was more serious, cape weed and cluster clover being present. The lucerne plants, however, had made splendid progress, and a heavy crop of hay was cut from the paddock.

Frost, A. C.

This paddock was cleared several years ago, and has been used for pasture. It is situated on the bank of the Preston river, but on a considerably higher level. Much couch grass and subterranean clover were present in the pasture. A crop of oats was sown in the 1936 season. The paddock was ploughed in January, 1937, one ton of agricultural lime applied and turned in during May, and a cultivation and harrowing carried out twice during the winter. Cultivation with a Sunpalm renovator was carried out in early September. Five and one-half bags of super were applied over 3 acres, and the paddock was then rolled and again harrowed. Two days later inoculated seed was sown broadcast at the rate of 10 lbs. per acre. After sowing, one half of the paddock was rolled and the other half harrowed. Good germination resulted from the whole plot, and a further stroke of the harrows was given at the end of November in order to conserve moisture. The plants were topped when about 9 to 12 inches high. In May, 1938, it was seen that the competition from couch was going to weaken the stand, but at that time a very useful crop had been obtained. The plants were fairly even, and were up to 18 inches in height. Grazing had been carried out with a herd of 15 cows for 4 days for one hour each day, prior to the inspection. Following the inspection the grazing was continuous until the crop was reduced to about 6 inches. A really good crop was cut for hay in the late spring.

Further inspections will be carried out during this season (1939).

AGRICULTURAL PROBLEMS.

Agriculturists, pastoralists and primary producers generally, who may be having difficulties of any kind in connection with their production activities, are invited to communicate with the Agricultural Adviser of their district of the Department of Agriculture, when information and advice will be supplied free of charge.

Where identification of plant or stock diseases or insect pests is required, full details of symptoms should be forwarded and also samples of the diseased plant, animal tissue or insect where practicable. Plant tissue intended for examination by the Plant Pathologist should be wrapped in paper and not forwarded in airtight containers, and plant specimens for the Botanist should be pressed between newspaper and dried before despatch. With regard to animal tissue for microscopic examination, this should be forwarded in a solution of 10 per cent. formalin, or if of considerable bulk in a sealed kerosene tin containing a few ounces of formalin as a preservative. Living insects should be sent in suitable containers and dead specimens in methylated spirits.

The addresses and names of Advisers are as follows:—

Albany	H. R. Powell (Fruit); B. Williams (Dairying).
Bridgetown	A. Flintoff (Fruit); A. M. Tindale (Dairying).
Bunbury	M. Cullity.
Geraldton	N. Davenport (Government Buildings).
Gosnells	R. C. Owen.
Harvey	R. L. Cailes (Fruit).
Katanning	A. S. Wild.
Kalamunda-Roleystone	W. H. Read, c/o. Department of Agriculture, Perth.
Kununoppin	W. M. Nunn.
Manjimup	C. M. Scott.
Metropolitan, Gingin, Chittering ...	S. E. Bennett, c/o. Department of Agriculture, Perth.
Mundaring	V. Cahill.
Narrogin	A. T. Gulvin.
Vasse	J. M. Nelson.

A SOIL SURVEY OF THE DENMARK AGRICULTURAL RESEARCH STATION, DENMARK, WESTERN AUSTRALIA.

G. H. Burvill, Agricultural Adviser.

FOREWORD.

Soil surveys are designed to collect and collate information regarding soils, and essentially involve the recognition, description and mapping of the soil types of any area under examination. On account of soil variability, and the numerous factors interacting in soil formation, soil surveys are necessarily on a broad basis, and boundaries between soil types are usually not sharp. Furthermore, so many factors affect plant growth that a perfect correlation between soil type and crop returns cannot be expected. The value of the soil survey lies in the systematic, if general, description of the soils of an area and their classification on the basis of such recognisable features as profile—the colour and texture (heaviness, etc.) of the layers exposed when a hole is dug—drainage, underlying rocks, vegetation associations, topography, etc. These features all affect plant growth or reflect fertility levels, so that such a classification represents an addition to knowledge of soil conditions which, when interpreted, will facilitate and rationalise agricultural development. Even the broad land classification carried out by surveyors made possible systematic land settlement in Western Australia in the face of natural difficulties, and there is no reason to doubt that the more modern soil survey will make a further substantial contribution to efficiency in Western Australian agriculture.

The Department of Agriculture, in association with other organisations, has been engaged on soil surveys in Western Australia over the last 10 years, and has mapped over 1,250,000 acres in detail with respect to special problems such as soil salinity and nutritional disorders of stock. The information collected is being published as rapidly as possible as a basis for future work—that of interpretation in terms of agricultural practice.

The agricultural areas of Western Australia cover approximately 70,000,000 acres. It would obviously be impossible to subject the whole of this huge area to a detailed soil survey in a reasonable time so that, as a step in the direction of diagnosing and elucidating soil problems, "spot" surveys are being made of representative sections throughout the agricultural portion of the State. By this means, and by assuming that a few thousand acres represent a district of 100 times that area, a body of valuable information will be gathered as a basis for experimental and advisory work. A number of "spot" surveys have already been undertaken in connection with various soil problems in several districts, and the soil survey of the Denmark Research Station by Mr. G. H. Burvill represents one of these. It is published as a record of the soil conditions on a farm being used for research purposes for the benefit of the south coastal areas.

L. J. H. Teakle.

SUMMARY.

A soil survey has been made of the Denmark Agricultural Research Station comprising 210 acres of land adjoining the Denmark River.

Fourteen soil types, exclusive of alluvial areas, undifferentiated wet soils and river sandbanks have been recognised, described and mapped. Of these, nine are types recognised in a larger district survey, while the remaining five are new types.

The soils have been grouped on the basis of profile features, reaction, parent rock, drainage, etc., into three main groups, with several ungrouped soils. Group I. soils are grey, yellow, and light brown sands more or less gravelly, with yellow to white clay subsoils. The pH of the surface soil is 5.5-6.0. Group II. soils are well podsolised grey sands, with "coffee rock" or ferruginous hardpans or coffee-stained layers in the subsoil; the surface pH is 4.4-4.8. Group III. soils are chocolate, dark grey and brown loams with clay subsoils, and are formed over basic rocks. The surface pH is about 6.

The relationship of the soil types to pasture development is briefly discussed. While considerable success has been achieved in pasture establishment on the soils of Groups I. and III., the soils of Group II. present special difficulties which are now being investigated. Group II. soils occur extensively in the Denmark and surrounding districts under a natural vegetation of stunted jarrah or scrub heaths of kangaroo "grass," bottlebrush, teatree, etc.

INTRODUCTION.

The Denmark Agricultural Research Station, formerly known as the Denmark stud farm, now comprises about 210 acres of land adjoining the Denmark River and lying north-east of, but close to, Denmark township. It was established in 1912 after a visit to the district of the Hon. T. H. Bath, then Minister for Agriculture, who decided that a demonstration and experimental dairy farm should be established to impart practical information to farmers of the district in dairying and its allied branches. The original farm taken over from the Lands Department comprised only about 27 acres on the right bank of the river; this piece surrounds the farm buildings but forms only the south-west corner of the present station. Additions of land were made from time to time till the station reached its present area in 1927.

In addition to studying the general problems of pasture and fodder production and conservation, an important function of the Research Station has been the maintenance of a herd of pedigreed Guernsey cattle and the breeding of pedigreed Berkshire and Tamworth pigs. In the earlier years small butter and bacon factories were also in operation at the Station.

CLIMATE.

The climatic features of the Denmark district have been discussed in some detail by Hosking and Burvill (1938) in C.S.I.R. Bulletin No. 115, "A Soil Survey of part of the Denmark Estate." The annual rainfall is 48 inches, of which about three-quarters falls in the May-October period, but no month of the year has an average of less than one inch. Temperatures are mild even in the summer months and winter frosts are uncommon.

NATURAL VEGETATION.

Prior to clearing, the main vegetation associations of the Denmark district seem to have been represented on the Research Station. Karri (*Eucalyptus diversicolor*) forest associations appear to have predominated in the south-western parts, while jarrah (*E. marginata*)—marri (*E. calophylla*) associations, and wet heath associations, including bottlebrush and kangaroo "grass," with scattered paperbark and blackbutt, occur on the eastern and northern sections. Further details are given in discussing the individual soil types.

PHYSIOGRAPHY AND GEOLOGY.

The highest parts of the Station are along its eastern and north-eastern boundaries whence drainage west to the Denmark River follows three main creek courses.

Slopes are mostly quite gentle compared with some parts of the district. No elevations have been determined east of the river, which is here close to sea level, but the highest point is probably not above 200 feet. The river course is well defined in most places by steep banks rising in places to about 15 feet above summer level, so that only small areas of the Station are liable to winter flooding by the river.

Several interesting features of the geological history of the area have been revealed by the soil survey. As in the district to the west, most of the outcropping rocks are either acidic and gneissic or of a basic, igneous character, and with them, certain soil types are usually associated (see later). However, rounded quartz gravel was frequently found in the upper sandy layers in soils of several types, especially in the north-east of paddock 14, the south-west of paddock 18, and to the south of the creek in paddock 17. This gravel was up to an inch long and occasionally of greater size. In the north-east of the Station an area of deep sandy soil of the Willbay series was found to contain much well rounded, as well as more angular, quartz grit, up to about ¼ inch in size, from near the surface to a depth of eight feet. Such occurrences, which appear to be deposits of transported materials, must be an important guide to the geological history of the area, and further, they indicate the complex character of the parent materials of the soils. This is discussed more fully in the next section.

Ferruginous laterite gravel and some boulders are associated with several soil types, but no areas completely covered with massive laterite boulders occur. The gravel pit near the west side of paddock 18 shows rounded quartz gravel among the more common ferruginous laterite gravel. Some of these rounded quartz pieces are cemented into ironstone lumps which appear to have been formed by a secondary cementation of the gravel deposits. The ferruginous gravels occurring in various soil profiles are not uniform in character. When found in the surface layers in types such as the Wakundup very gravelly sand and the Koorrabup very gravelly sand, they are usually fairly smooth in outline and do not appear, on breaking, to contain much quartz sand. On the other hand, ferruginous gravels from subsoil layers are very irregular in shape and often include much quartz sand. It is thought that these latter gravels may be the result of pedogenic processes under the present climatic conditions, while much of the surface gravel may be residual from a former climatic cycle and has been exposed by subsequent land movements and geological erosion.

DESCRIPTION AND CLASSIFICATION OF THE SOILS.

General.

The soil survey of about 16,000 acres in the Denmark district reported by Hosking and Burvill (1938) in C.S.I.R. Bulletin No. 115 was used as a background for the classification of the soils of the Research Station. A number of the soil types recognised in the larger survey occur on the Research Station, though in some cases they show variations from the general type description which makes it desirable to consider them as specific phases. Further, five new series designated B, C, D, E, and F, which were not recognised in the district survey, have been mapped on the Research Station, the survey of which was on a more intensive basis and thus allowed more attention to be given to soil variations which may have been submerged in the more inclusive groupings of a broader survey.

Fourteen soil types, exclusive of alluvial areas, undifferentiated wet soils and river sand banks have been mapped, principally on the basis of soil profile features. The order of the following descriptions is intended to bring out relationships between the types. Further, they have been divided into broad groups on the basis of certain general similarities, and it is likely that methods for pasture establish-

ment and management will be generally similar for the types within each group. The extent of each of the soil groups, types and phases is given in Table 1.

TABLE 1.

AREAS OF SOIL TYPES MAPPED ON DENMARK RESEARCH STATION.

Soil Type.	Symbol.	Area.
Group I.—		acres.
Wakundup very gravelly sand	Wvgs	7·5
Wakundup gravelly sand grey phase	Wgs	6·2
Wakundup gravelly sand brown phase	Wgs	17·1
Type B loamy sand	Bls	10·0
Type C sand	Cs	16·7
Koorrabup very gravelly sand	$K^{o}vgs$	3·7
Koorrabup gravelly sand	$K^{o}gs$	8·9
Group I. Subtotal	....	70·1
Group II.—		
Kordabup sand	$K^{b}s$	11·9
Kordabup sand hardpan phase	$K^{b}s/_{H}$	8·2
Kwilalup sand	$K^{w}s$	28·5
Type D sand	Ds	11·2
Plantagenet peaty sand	Pps	41·5
Willbay sand	$W^{b}s$	6·5
Group II. Subtotal	....	107·8
Group III.—		
Koorundurup gravelly loam	$K^{r}gl$	3·1
Type E gravelly loam	Egl	6·8
Group III. Subtotal	....	9·9
Ungrouped—		
Type F sandy loam	Fsl	11·9
Alluvial soils	A	5·5
Undifferentiated wet soils	U	2·5
River sandbanks	....	1·6
Rock outcrops	....	0·7
Total (acres)	....	210·0

These areas include the land between the surveyed river traverse and the river's edge, also the closed east-west roads in paddocks 16 and 20, but the north-south surveyed road through the Research Station is excluded.

The complexity of the soils on the Research Station must be in part attributed to their association with the Denmark River, the course of which has undoubtedly changed as geological erosion has progressed towards the present topography. Deposits of alluvial and colluvial origin have formed the parent materials of types C and D and possibly F, as well as the more recent alluvial areas mapped A.

As previously mentioned, acidic gneissic rocks and also basic igneous rocks outcrop in various places along the river banks and away from the river. With the acidic rocks, soil types such as the Wakundup gravelly sand, the Koorrabup gravelly sand and a new type B loamy sand are associated, while over the basic rocks occur the Koorundurup gravelly loam and a redder soil (type E gravelly loam) showing some relationship to the Scotsdale soils. It might be thought that such soils have developed from the weathering in situ of these rocks, but the occurrence of rounded quartz gravel and grit in several soil types reveals the importance of transported materials in this area. It seems probable, therefore, that even types such as the Wakundup gravelly sand, the Koorrabup gravelly sand and the Kordabup sand, which have yellow clay subsoils at about two feet, and show signs of decomposing gneissic rock at about four feet, may have their surface sands derived partly—even largely—from transported sands, rather than from the weathering in situ of such basal rock.*

Details of the Soil Types.

Group I.

Grey, yellow and light brown sands, more or less gravelly, with yellow to white clay subsoils. Originally timbered with karri and/or jarrah and marri.

Types Mapped.

Wakundup very gravelly sand	Wvgs
Wakundup gravelly sand grey phase	Wgs (hatched)
Wakundup gravelly sand brown phase....	Wgs
Type B loamy sand	Bls
Type C sand	Cs
Koorrabup very gravelly sand	K°vgs
Koorrabup gravelly sand	K°gs

In this group the surface soils are slightly to moderately acid with a pH range of 5.5-6.0. The subsoils are of similar reaction generally but type B loamy sand showed a very acid subsoil and deep subsoil. (See Table 3.)

Wakundup Series.

This series, whose soils are very extensive in the district and most widespread of the developed karri hill soils, is represented on the Research Station by both its recognised types, the *Wakundup gravelly sand* (Wgs) and the *Wakundup very gravelly sand* (Wvgs). Both the grey and brown phases of the former occur and conform closely to the type descriptions given by Hosking and Burvill (1938) in C.S.I.R. Bulletin No. 115, *i.e.*, their profiles show grey, yellow grey and light brown

* This view is supported by mineralogical examinations of subsurface and subsoil samples made by Dr. Dorothy Carroll, Department of Geology, University of W.A. The fine sand fractions of the subsurface samples from profiles of Koorrabup gravelly sand and type B loamy sand were made up principally of rounded and subangular grains, while in the clay subsoils the grains were largely angular and subangular, and larger angular quartz pieces belonging to the weathered bedrock occurred. In one profile studied there was a smaller assemblage of heavy minerals in the subsoil than in the surface. Since the underlying rock is probably a gneissic granite, the rounded grains in the upper layer of the profile and the mineralogical composition of that layer indicate that it is probably transported.

loamy sands, with more or less laterite and quartz gravel, passing at 18 to 24 inches usually to yellow "short" clay. Outcrops of acid gneissic rock are associated with several areas of this type. The Wakundup very gravelly sand occurs along the Scotsdale Road boundary, and on the high land in the central part of the Station. The yellow to light brown very gravelly sand is over 3 feet deep in many places, and laterite boulders are fairly common in the soil and around trees. Quartz grit was found to occur in a layer above the yellow sub-soil clay in some places, and rounded quartz gravel was also noted in the gravel pit in paddock 18.

The Wakundup soils are mostly cleared but appear generally to have supported a karri-marri-buloke (*Casuarina decussata*) vegetation association. Jarrah is known to have grown on a few areas mapped in this series.

Type B loamy sand (Bls).

This type is characterised by a subsoil of white or pale yellow "short" clay with a talc-like feel which seems to have developed from a very acid gneissic rock. The overlying soil, which is generally 20 to 30 inches deep, rather resembles the grey phase of the Wakundup gravelly sand. Below 4 to 6 inches of grey loamy sand with organic matter, a grey to yellow grey loamy sand or sandy loam occurs with varying amounts of quartz gravel. A grey brown soft gravel of low density occurs in some profiles, and small light brown concretions with a charcoal nucleus also occur in the surface layers. Grit and gravel are usually most dense in a layer of several inches above the subsoil clay which, if not light grey or white when first encountered, becomes more white and short and "taley" with depth. Decomposing rock has been found below 3 to 4 feet and also observed at the well on the hilltop in the main area of this type. The deep subsoil layer (42in.-60in.) where sampled was strongly acid (pH 3.98).

The main occurrence of type B is in the central parts of the station associated with the Wakundup soils, though it has been vegetated by a jarrah-marri association, not with karri. Observations after 7 inches of rain in January, 1939, and statements from others, indicate that this soil becomes more or less waterlogged in winter, presumably through seepage from the areas of Plantagenet peaty sand which lie to the east of it and at somewhat higher elevations.

Type C sand (Cs).

In appearance this type also seems to have affinities with the Wakundup soils, but most often no clay horizon was found within 42 inches of the surface. The location of the mapped areas suggests that colluvial and alluvial deposits adjacent to the river and creeks, or at the foot of slopes, have formed the parent materials of the type. The profiles show grey, yellow grey, yellow, light brown, and occasionally brown sands or loamy sands mostly more than 42 inches deep and, as usual, the surface layers show some darkening by organic matter. Gravel is often absent or occurs deep in the profile below 27 inches. Yellow sandy clay loam or sandy clay was found below 30 inches in some places. The area adjoining the river in the western part of paddock 20 occurs as a number of ridges with several moist hollows between, and represents old river sandbanks, now well above river level. The clay beneath the sand at the foot of one ridge, and also in a moist hollow, was a grey sticky plastic clay under which a sand layer was found in one boring, suggesting alluvial origin.

A timber association of well grown jarrah and marri was the native vegetation of some areas of this type, while in other cases karri has grown on these soils.

Koorrabup Series.

The two recognised types of this series (see C.S.I.R. Bulletin No. 115) have both been mapped on the Research Station, but as specific cases. The *Koorrabup gravelly sand* (Kogs), a common type in the district under jarrah-marri vegetation associations, occurs principally as a *deep phase* with only a little ferruginous gravel. Instead of about two feet of yellow sand, more or less gravelly, overlying a yellow or yellow brown clay, the sand was mostly over 3 feet deep with gravel confined to its lower parts. A type sample from paddock 20 showed the usual yellow clay (with gravel embedded in it for a few inches) at 4 feet. The clay became mottled yellow, red brown, and white with depth, and gritty decomposed rock and clay were found below 5 feet.

The *Koorrabup very gravelly sand* (Kovgs), of which the A horizons of yellow to light brown very gravelly sand are usually over 2 feet deep, occurs in paddock 20 as a *shallow phase* with clay at 12 to 15 inches. The gravel is principally ferruginous (laterite) but some quartz pieces were also noted. The Koorrabup types resemble rather closely the Wakundup gravelly sand, brown phase, and the Wakundup very gravelly sand, though the A horizon sands are usually more yellow in the Koorrabup types and rather brownish in the Wakundup soils. A well grown jarrah-marri, *Banksia grandis* association is characteristic of the Koorrabup soils.

Group II.

Includes well podsolised grey sands with "coffee rock" or ferruginous hardpans or coffee stained layers in the subsoil. Vegetation varies from well grown or stunted jarrah-marri associations to open wet heath associations of bottlebrush, kangaroo "grass," rushes, stunted blackbutt and paperbark.

Types Mapped.

Kordabup sand	....	$K^{b}s$ and $K^{b}s/_{H}$
Kwilalup sand	....	$K^{w}s$
Type D sand	....	Ds
Plantagenet péaty sand	....	Pps
Willbay sand	....	$W^{b}s$

These soils are generally the most acid soils of the area, the surface soil averaging about pH 4.6, compared with pH 5.6 for the soils of Group I. and pH 6.0 for the types of Group III.

Kordabup Sand ($K^{b}s$ *and* $K^{b}s/_{H}$).

This type, like the Koorrabup soils, carries a jarrah-marri vegetation association in its virgin state, but its profiles, while grading into those of the Koorrabup gravelly sand, are typically well podsolised. Two phases, a *variable hardpan phase* and a *well developed hardpan phase* are described in C.S.I.R. Bulletin No. 115, and both occur on the Research Station in conformity with those descriptions. Quartz grit and gravel and ferruginous gravel occur in varying amounts especially in the variable hardpan phase. The area in paddock 14 has a large amount of rounded quartz grit and gravel in the sandy layers, clearly indicating that these layers must be transported materials.

Kwilalup Sand ($K^{w}s$).

This soil type occurs fringing the open kangaroo "grass," bottlebrush, paperbark areas of the eastern part of the Station, and also on the slopes between the Koorrabup gravelly sand and the river in Paddock 20. It is a well developed

podsol with a dark brown "coffee rock" hardpan of variable thickness, commencing usually 18 to 24 inches below the surface. Profiles of this type grade into those of the Plantagenet peaty sand, where, however, coffee rock, if it occurs at all, is usually below 36 inches. There is also a relationship to type D (see below).

The surface soil of the Kwilalup type is sand with sufficient organic matter to impart a grey to black colour somewhat darker than in the Kordabup sand. This passes gradually to grey or light grey sand in the A_2 horizon. Below this more or less bleached layer, but above the coffee rock proper, a soft brownish black cement, probably organic, occurs in some profiles as a layer one to two inches thick. The coffee rock, which may be up to a foot in thickness, is dark brown (coffee coloured) at first, but becomes more yellow and gritty with depth. In some cases it passes directly on to yellow clay, but in other profiles about a foot of yellow sand or clayey grit occurs below the coffee rock before clay is reached. In a type sample boring, yellow plastic clay underlay the coffee rock, then yellow, red and grey mottled clay which passed into sandy clay below 4 feet and clayey sand at 6 feet. Below this was light grey fine sandy clay. This succession of layers of variable texture suggests again the importance of deposits of transported materials as parent materials of some, at least, of the Denmark soils.

Other details of the Kwilalup sand are given in C.S.I.R. Bulletin No. 115. The vegetation on this type consists of stunted jarrah and marri, odd paperbark (*Melaleuca sp.*), sheoak (*Casuarina Fraseriana*), *Adenanthos obovata*, Southern Cross (*Xanthosia rotundifolia*), blackboys (*Xanthorrhoea Preissii*), and some kangaroo "grass" (*Evandra aristata*), teatree (*Agonis parviceps*) and bottlebrush (*Beaufortia sp.*).

Type D sand (Ds).

This type is a strongly podsolised sand related to the Kwilalup sand, but instead of a fairly hard coffee rock, it shows usually a B horizon of coffee coloured sand not cemented or only weakly cemented. This layer commences at 18 to 36 inches from the surface and is up to 12 inches thick, then passing into yellow, or yellow grey or grey sand. Clay seldom occurs within 42 inches. The A horizon consist of dark grey or grey black sand with organic matter, becoming light grey to white at about 12 inches. Rounded quartz gravel has been found in some profiles and ironstone gravel may occur below 36 inches.

Type D appears to have developed on old colluvial and alluvial deposits of deep sand and seems closely related to type C in this respect. Areas of types C and D often occur together in fact. It has been noted that areas of type D are often sufficiently moist in summer from seepage to promote a good growth of Paspalum. Round rushes occur in scattered clumps on cleared areas.

The type appears to have supported a jarrah-marri vegetation association of better grown trees than on the Kwilalup sand.

Plantagenet peaty sand (Pps).

This type, which embraces the soils of the wet heaths—open kangaroo "grass," bottlebrush, blackboy "flats"—in the country west of Denmark is fully described by Hosking and Burvill (1938). It has formed on sandy deposits 6 feet and more in depth, which must have accumulated in the course of geological erosion to form the present topography. Restricted drainage causes these areas to be very wet in winter, and even in mid-summer the upper layers are usually moist and free water sometimes occurs within 3 feet of the surface.

On the Research Station two main areas occur adjoining the eastern boundary. The surface of grey black or dark grey sand is matted with roots and decomposed organic matter so that a layer of one to three inches is often rather peaty. The

organic matter decreases with depth and the sand is light grey to white below 12 inches. Dark brown streaks sometimes appear below 2 feet, and below 3 feet a soft brownish black cement or soft coffee rock occurs in some profiles, while in other cases the light grey sand with some dark brown staining continues to 6 feet. Quartz grit and gravel occur in the profiles of some areas but ironstone gravel is not found.

While the natural vegetation is usually scrubby, stunted jarrah occurs scattered in some parts, and quite large blackbutt (*Eucalyptus patens*, up to 30 feet) grows on other areas. The principal members of the vegetation noted on the Research Station were kangaroo "grass," bottlebrush, teatree, blackboy, paper bark, various rushes, green kangaroo paw (*Anigozanthos flavida*) and moss, with stunted jarrah and blackbutt.

Willbay sand (W^bs).

This is also developed on deep sandy deposits, but is better drained than the Plantagenet peaty sand and supports a timber vegetation association. The area in the north-east of the Station has been mapped as a *very gritty phase* because, to a depth of 8 feet, the sand contains much well rounded, as well as angular, quartz grit. Blackish grey sand, with organic matter and roots near the surface, passes to grey and then light grey gritty sand at about 12 inches. In a type sample boring this continued with odd brown stainings to 8 feet. The next 6 inches consisted of successive layers of grey sand and yellow gritty sandy clay loam, then a pale fawn gritty clayey sand continued for 8 inches to the maximum depth of boring, 110 inches. No free water was found, although 6½ inches of rain had fallen in the previous week.

The vegetation on this area includes sheoak, stunted jarrah, blackboy, teatree, *Pultenea reticulata*, various rushes, odd bottlebrush and prickly or holly leaved banksia (*Banksia ilicifolia*).

Group III.

This includes soils formed over basic rocks. As in the district survey, they have been found to be the least acid soils of the area with pH value about 6 (see Table 3).

Hosking and Burvill (1938) describe two soil series, the Scotsdale and the Koorundurup, developed on basic rocks. Of these, the latter is represented on the Research Station by the Koorundurup gravelly loam (K^rgl) but no typical Scotsdale profiles were found, and a new type, E gravelly loam (Egl), has been mapped to include soils showing some features of the Scotsdale soils.

Koorundurup gravelly loam (K^rgl).

This occurs in the bull paddock (No. 8) and south of the river in paddock No. 11. It has a chocolate to dark grey sandy loam to clay loam surface, sometimes gravelly, which passes below 6 inches into dark grey and dull yellow mottled very plastic clay. Sometimes brown and red colours occur with depth in the mottled clay and greenish decomposing basic rock may occur below 2 feet. Areas of this type are relatively flat and basic rock outcrops (? diorite) are associated with them.

Type E gravelly loam (Egl).

This occurs principally in paddocks 11 and 11A up the slope from the Koorundurup gravelly loam. Basic rock outcrops are again a characteristic feature. The soil profiles show the following features:—

(a) A few inches of dark brown loam which may be gravelly and which is darkened by organic matter.

(b) Brown to red brown loam or clay loam changing to brown clay at about 12 inches. Some fine soft gravel as in the Scotsdale soils sometimes occurs.

(c) Yellow and grey mottled plastic clay at about 18 inches. Sometimes brown and red brown colours also are noted.

(d) Decomposing basic rock with green, yellow and brown colours, representing the C horizon, was found at 42 inches in a type sample boring.

Ungrouped Soils.

Type F sandy loam (Fsl).

This is the main soil type occurring on the oldest parts of the Research Station between the Scotsdale road and the river, but does not occur in that part of the district covered by the soil survey reported in C.S.I.R. Bulletin No. 115. It was probably timbered originally with karri, and appears to be formed on old alluvial deposits. The surface colour and texture are not uniform throughout the area, but there are no well marked boundaries and the subsoil features are fairly consistent so that no subdivision has been attempted.

The surface soil, which is darkened by organic matter and has no doubt been ploughed in these old paddocks, is grey, grey brown or dull brown loamy sand, sandy loam or loam, sometimes with slight gravel. This passes at about 9 inches into yellowish grey or grey brown sandy clay loam or sandy loam. Clay increases with depth and a dull yellow sandy clay is found at 15 to 18 inches. Below 20 inches the sandy clay or clay becomes mottled grey, yellow and red or brown. In a type sample boring the clay became gravelly and more sandy at 48 inches. The ferruginous gravel and also quartz grit continued to 6 feet, the depth of boring.

Some areas with browner and more gravelly surfaces than usual occur in the north part of the bull paddock (No. 8) and are included with type F sandy loam.

Alluvial Areas (Mapped A).

Alluvial deposits of relatively recent origin occur along the banks of the river in places, and the creek flowing from the east through paddocks 17 and 13 has developed a moist alluvial flat near its junction with the river. According to old records, this area was originally a dense paper bark swamp, and the creek course has been straightened and deepened since clearing to improve drainage. All the alluvial areas mapped are liable to, or just out of reach of, winter flooding.

The profiles of these areas usually show variations in texture due to layering of deposits. On the main area in paddocks 13, 11A and 12 the surface varies from grey fine sandy loam to a grey black organic loam. At 3 to 12 inches depth a dark grey or black clay occurs. This may become more yellow with depth and generally becomes more sandy. Below 2 feet layers of light grey or grey and yellow clayey sand or sand are found, and further sandy clay lies below 3 feet. Other alluvial areas have mostly grey sand or sandy loam surfaces, with grey or black clay at about 9 to 18 inches. Layers of sands and sandy clays, mottled grey and yellow, occur to the usual depth of examination (42 inches).

Rusty mottlings are common in the surface soils indicating periodical waterlogging.

Undifferentiated Wet Soils (U and swamp symbols).

Areas where springs occur on slopes or where seepage keeps the soils permanently moist are not included with other soil types, but are grouped as undifferentiated wet soils. Such areas may be very useful for summer pasture.

River Sandbanks.

In the main bend of the river east of the farm buildings occur sandbanks apparently deposited from the river floodwaters near the junction with the creek which enters from the east at this point. The sand on these banks is grey at the surface due to organic matter and yellow to orange below about 6 inches.

Rock Outcrops.

A few areas consist mostly of outcropping rock—some acidic and gneissic and some basic—with practically no soil, and are mapped as rock outcrops.

LABORATORY EXAMINATION OF TYPE SAMPLES.

Hosking and Burvill (1938) have reported a comprehensive range of chemical data on the soils of the Denmark district, and in the present work the laboratory examination has, therefore, been restricted to the determination of gravel and stone in the field samples, of reaction (pH), and of conductivity and chloride for a number of subsoils.

Gravel and Stone.

As their names imply, several of the soil types contain considerable amounts of gravel (greater than 2 mms). The amounts determined in the type samples are shown in Table 2, from which it is seen that the surface and subsurface layers of types like the Wakundup very gravelly sand and the Koorrabup very gravelly sand range from 52 to 81 per cent. gravel. The Koorrabup gravelly sand on the Research Station is not gravelly in its surface layers, but big laterite stone and gravel has been found at the bottom of the A_2 horizon—the type sample contained 48 per cent.

The soils of Group II. are generally not gravelly in the surface and subsurface layers. The Kordabup sand (no type sample) is an exception and may contain ironstone and/or quartz gravel. Rounded quartz gravel was also found in some profiles of Kwilalup sand and type D sand.

The "coffee rock" hardpan of the Kwilalup sand, contained 44 per cent. of gravel when sieved after gentle grinding. The gravel contained several rounded quartz pebbles but was made up principally of dull yellow, rather soft ferruginous gravel of irregular shape. Some of the larger pieces showed on breaking a dark brown hard centre suggesting that the gravel may be undergoing hydration and softening from the outside.

The deep subsoil of type D sand contained 9.7 per cent. gravel. This was ironstone gravel of very irregular shape and contained a large proportion of quartz sand cemented by the iron oxides. It may be forming at present with seasonal fluctuations in water table causing alternations of oxidising and reducing conditions. The Willbay sand occurs on the Research Station as a very gritty phase and hence has much higher gravel percentages (up to 21 per cent.) than occur in the normal phase. The grit is mostly less than 5 mms. in size and consists principally of quartz including many well rounded pieces. Several larger rounded quartz pebbles occurred in the deep subsoil.

The soils of Group III., formed over basic rocks, contained variable amounts of gravel apart from odd stone floaters in the profiles. Small, hard, dark brown ferruginous gravel is characteristic of the surface and subsurface, while some angular quartz fragments and very small pieces of decomposing rock also occurred in the subsurface sample of type E gravelly loam. Small, soft, reddish brown gravel as described by Hosking and Burvill (1938) for the Scotsdale series was also noted in some of the profiles of this type.

TABLE 2.

GRAVEL AND STONE (GREATER THAN 2MMS.) IN TYPE SAMPLES—DENMARK RESEARCH STATION, EXPRESSED AS PER CENT. OF FIELD SAMPLE.

Horizon.	Group I.				Group II.				Group III.		Ungrouped.	
	Wvgs	Bls	K^{o}vgs	K^{o}gs	K^{w}s	Ds	Pps	W^{b}s	K^{r}gl	Egl	Fsl	A
	%	%	%	%	%	%	%	%	%	%	%	%
Surface (A_1)	52·4	1·8	57·4	*Nil*	Trace	*Nil*	*Nil*	8·6	1·2	*Nil*	3·3	*Nil*
Subsurface (A_2)	81·2	†4·0 26·3	62·9	†*Nil* 48·0	Trace	*Nil*	Trace	20·9	2·0	‡8·7	*Nil*	*Nil*
Subsoil (B)	*32·6	0·1	13·4	51·0	44·1	Slight	Trace	15·7	Odd big stones	*Nil*	*Nil*	Trace
Deep subsoil (C)	*disc.	0·9	11·5	0·7	0·8	9·7		9·6	...	2·2	†2·2 23·7	Trace

* Samples contaminated from A horizons. † Gravel mostly in lower part of these horizons. ‡ Includes a stone floater which accounted for most of this weight.

TABLE 3.

REACTION* (pH) OF TYPE SAMPLES—DENMARK RESEARCH STATION.

Horizon.	Group I.				Group II.				Group III.		Ungrouped.	
	Wvgs	Bls	K°vgs	K°gs	K^{w}s	Ds	Pps	W^{b}s	K^{r}gl	Egl	Fsl	A
Surface (A_1)	5·52	5·64	5·64	5·72	4·74	4·64	4·38	4·79	6·06	5·88	5·45	4·73
Subsurface (A_2)	5·96	5·94	5·42	5·64	4·98	5·30	4·81	4·98	5·74	6·38	5·92	4·64
Subsoil (B)	5·92	4·49	5·96	5·60	5·14	5·59	4·38	5·42	6·08	6·29	5·39	4·54
Deep subsoil (C?)	4·66	3·98	5·31	5·59	5·09	5·64	...	4·48	...	6·62	4·75	4·41

* Determined on 1 : 5 extract using the quinhydrone electrode.

The sampled profile of type F sandy loam contained a notable amount of gravel in the deep subsoil. As with type D sand this was ferruginous gravel of irregular shape and contained a large amount of quartz sand. Its formation may be associated with seasonal fluctuations in the water table. The gravel of this layer also included a small proportion of quartz pieces some of which were well rounded. This supports the suggestion that this soil type appears to be formed on old alluvial deposits.

Reaction (pH).

The pH values for the type samples are shown in Table 3 from which it is seen that the most acid soils are in Group II. and the least acid in Group III. In Group I., for all profiles, the deep subsoil has the lowest pH, that for type B loamy sand falling to 3.98. On the contrary, in Group II., for all types except the Willbay sand the surface soil is more acid than the lower layers of the profile.

Water Soluble Salts.

To obtain a measure of the water soluble salts in the subsoils and deep subsoils of a number of types, conductivity determinations were carried out on the 1:5 soil : water extracts. Chlorides were determined by Best's method using the silver-silver chloride electrode. The results are given in Table 4 in which chlorides are expressed as sodium chloride, while the Specific Resistance gives a measure of the total water soluble salts—the *lower* the Specific Resistance the *higher* the concentration of salts.

TABLE 4.

SPECIFIC RESISTANCE AND SODIUM CHLORIDE DATA FOR SUB-SOILS AND DEEP SUB-SOILS—DENMARK RESEARCH STATION.

Serial No.	Type.	Depth.	Specific Resistance 1 : 5 Extract. (60°F.)	Sodium Chloride (Per cent. Oven-dry Soil).
	Group I.—	ins.	ohms.	%
2678	Wakundup very gravelly sand	54—60	8,900	·027
2688	Koorabup very gravelly sand	24—36	11,600	·020
2689	do. do. do.	36—60	12,700	·017
2695	Koorrabup gravelly sand	58—69	13,100	·017
2705	Type B loamy sand	24—42	4,120	·060
2706	do. do.	42—60	2,750	·093
	Group II.—			
2720	Kwilalup sand	32—41	8,900	·025
2721	do.	41—50	6,900	·032
2701	Willbay sand	96—110	10,600	·017
	Group III.—			
2729	Koorundurup gravelly loam	18—30	7,700	·018
2725	Type E gravelly loam	13—33	6,050	·023
2726	do. do. do.	33—42	7,400	·022
	Ungrouped—			
2683	Type F sandy loam	30—48	3,940	·033
2738	Alluvial soil	32—42	1,455	·15

The figures call for little comment. They indicate that in general both total salts and chlorides occur in small quantities only. The figure of 0.15 per cent. sodium chloride in the alluvial soil profile from paddock 13 may represent a moderate accumulation by seepage during the summer from the surrounding higher land.

RELATIONSHIP OF SOIL TYPE TO PASTURE DEVELOPMENT.

It has been mentioned earlier that the soils of the Research Station fall naturally into groups on the basis of such factors as profile features, reaction, parent rock, drainage, etc. From the standpoint of pasture development the types within these groups may be expected to have certain common features, and this has in fact been the experience in the Denmark district. Most of the pasture establishment has been on the karri and jarrah hill types of Group I. and Group III., principally the former, since soils formed over basic rocks (Group III.) are not very extensive. On the other hand, the development of the more acid podsols of Group II. has not been extensively undertaken and there has been a number of disappointments where attempts have been made. These strongly podsolised types are very extensive in the south coastal areas, and their successful development would greatly improve the carrying capacity of many partly developed farms, as well as point the way to the opening up of further new areas when desirable. It is therefore fortunate that the Research Station has available for experimental purposes areas of types such as the Kordabup sand, Kwilalup sand and the Plantagenet peaty sand, the latter two being, of course, the common soils about Denmark on the open kangaroo "grass," bottlebrush flats, and the bordering stunted jarrah country.

It cannot be assumed that experience on one soil type, within Group II., say, can be applied without modification to all the types of the group. For instance in Paddock 20, the area of Kordabup sand hardpan phase, has developed quite a fair mat of subterranean and hop clovers while the Kwilalup sand on several parts of the Station has so far given very poor results with subterranean clover. Also, several areas of Type D sand, with profiles generally similar to the Kwilalup sand, carry good swards of Paspalum and subterranean clover. Yorkshire fog and drooping flowered clover seem more tolerant of the conditions unfavourable to subterranean clover, and these two were noted scattered over parts of the area of Plantagenet peaty sand in paddock 17. There is a hope that a "minor" element—copper—may prove to be a decisive factor in successful pasture establishment on the Plantagenet and Kwilalup soils.

The most successful established perennial pastures on the Station are on the types formed over basic rocks, and on type F sandy loam which is the most important soil on the oldest part of the Station. In these pastures perennial rye grass, cocksfoot and paspalum have been successfully established and the dominance of subterranean clover appears to have been overcome. The Group I. soils on the Station, including the important gravelly sands and very gravelly sands of the Wakundup and Koorrabup series, have shown their ability to grow excellent subterranean clover when fertilised with superphosphate. Their treatment and management to produce more mixed pastures including perennial grasses is an important district problem, and may reveal further individual characters of the soil types.

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REFERENCE.

Hosking, J. S., and Burvill, G. H.:

1938—A Soil Survey of Part of the Denmark Estate, Western Australia. C.S.I.R. (Aust.) Bull. No. 115.

GENERAL MANAGEMENT OF SHEEP.

HUGH MCCALLUM,
Sheep and Wool Inspector.

In dealing with a subject as comprehensive as the sheep industry, this article must necessarily be confined to brief references to the main points of interest, any one of which could quite easily be made the subject of an article in itself.

The co-operation between the farming community and the Department of Agriculture is increasing every day, and the exchange of information has been of great benefit and will be of still greater benefit. There are many important events that happen during the year in farmers' flocks which, if properly tabulated and investigated, would solve many problems in sheep breeding. Sheep on the farm are essential to enable the farmer to obtain the highest possible returns: therefore their management plays a definite part in the farm activities.

Western Australia has become a very large producer of sheep, wool and export lambs, but for her to rank as a premier producer changes are required in the methods of sheep breeding of many owners, who do not conduct their sheep husbandry operations as business men. Obsolete methods are not for the modern age, and "better type sheep and wool" must be the slogan. The breeders of high-class sheep are doing their part; they continue to progress. Production of quality sheep and wool must go on: in this way only can we hope to exploit this great source of wealth.

Whilst the improvement in the breeding sheep is one of the main objects to be attained, the question of losses through neglect, incorrect feeding and other causes, must be studied and means adopted to successfully combat them. Over-stocking and under-feeding are outstanding faults in management; the latter, in particular, should never occur in this State where reserves of feed can be conserved. A farmer should know the carrying capacity of the farm and stock accordingly with the type of sheep most suited for his district, remembering it is not numbers that count in sheep husbandry but quality.

To the beginner on the wheat lands merino sheep are recommended and the animals selected should be of good constitution and conformation, large-framed and growing fleeces of good value commercial wool.

As production is the main objective in sheep breeding, the flocks must be watched carefully to ensure that they do not deteriorate and lose their former vigour through the introduction of inferior sheep and the wrong type of rams. There are rules in sheep breeding which must be observed and one of the most important is to avoid breeding from extremes of type, a practice which, unfortunately, has been followed by many breeders.

Sheep and wool demonstrations and lecturettes at Agricultural Shows have done much to assist the farmer gain a knowledge of good type sheep. The improvement of the flocks requires much patience and perseverance and a fixed idea in the minds of breeders of the object to be attained. Good progress has been made in the industry, but there is still much to be learned, not only by the ordinary farmer but also by the more experienced man. The farmer should endeavour to become a good judge, in order to notice the bad, as well as the good points of an animal. He must know his flock intimately to decide the type to be retained and that to be culled, and this knowledge will enable him to accurately select or describe the type of rams required. The better the husbandry of the sheep, the stronger and healthier

will be the offspring, and they, it must be ever remembered, are the future flock. Frequent changes to different pastures and the supplementing in the diet of elements that are deficient in the soils, by means of licks, etc., add to the general health of the flock.

SELECTING THE RAMS.

The important business of selecting suitable rams to mate with the ewes calls for attention. In doing this the general character of the flock must be borne in mind and also the faults and defects which must be eliminated, as far as possible, in the next generation. To this end the sires should be exceptionally strong in those points where the ewes are faulty. Good quality, pure breeding and strong constitution are essential qualities of the ram, together with as much style and finish as it is possible to obtain, for on him largely depends the quality of the future flock. The stand of the animal should be examined; some rams stand square on their feet, others are very faulty; particular care should be taken to see that there is no inclination to weakness in the hocks—straight hocks and good action are outstanding points of a well-bred ram.

Farmers should purchase their rams from one of the registered stud breeders, who, generally speaking, are men who have made a life-long study of sheep breeding, or who, at least have a far wider experience in sheep raising than the average farmer. In purchasing from these breeders a farmer—in addition to obtaining his annual supplies—is gaining the benefit of their wider experience; again, he can be relatively sure of purchasing rams of sound constitution. This quality in a sheep is of fundamental importance and is largely the product of hereditary influence which stud breeders develop in their systems of breeding. Having selected the breeder whose rams give satisfactory results, the farmer is wise to purchase annual drafts of rams from him. Adherence to this policy and careful annual culling of the flock must quickly give good results.

SELECTING THE BREEDING EWES.

Often the farmer does not realise the importance of the ewes in building up a flock to his ideal type. They must be carefully selected for their requisite qualities. Leading characteristics which ewes should possess are constitution, conformation, trueness to type, vitality and fertility. With strong vitality the ewes can stand reverses, but they should be cared for, especially during gestation and at lambing time. Fertility is essential; no ewe that has failed to produce lambs should be kept on the farm. There are too many unproductive ewes retained year after year, for reasons difficult to understand. Good lines of "cast for age" ewes can be purchased from breeders off shears. Each season, after shearing, the older ewes are sold, the younger ones taking their place. Having been retained by the breeder for several years these sheep are generally a very even line and can be recommended.

Provided they receive fair treatment and good pastures, these ewes, when mated to rams of quality, will produce high grade lambs. Most of the good flocks pastured in the wheat belt were bred from sound-mouthed "cast for age" ewes. Even though they are cheap, broken-mouthed sheep should never be purchased.

It is not wise for the farmer to bargain unduly over the price asked by the vendor of good sheep. The time, cost and work involved in breeding up a uniform flock must be borne in mind and by starting on sound lines many years of unprofitable work in selecting, mating, breeding and culling are saved. Success or failure will depend entirely on the farmer's own ability.

The rams and the ewes should be in good condition before mating; ewes that are poor throughout the year cannot produce good lambs and the lambing percentages are always low. The lambs lack stamina and never develop into sheep which compare with those from flocks fed evenly throughout the year.

CLASSING THE FLOCK.

Before shearing each year the flock should be classed to permit of the rejection of all undesirable animals that do not come up to standard. The average farmer can with a little judgment cull many unprofitable sheep from the flock. The percentage of rejects will greatly depend on the standard of excellence set as the flock type. The retention of inferior sheep will retard the improvement of the flock and cause a marked deterioration in the quality of the wool produced. The returns of many farmers who do not class their sheep, in consequence, are much lower than those from flocks where culling is practised.

IMPORTANCE OF CORRECT MATING.

Many flocks have been ruined by introducing fresh blood strains or types quite unsuitable in general characteristics. Graded ewes are essential, as high-class rams cannot reasonably be expected to give the best results when mated to inferior dams. It is not possible to eliminate all defects at the one time, because any given characteristic cannot be fixed in one generation. Flock improvement by careful selection and mating is dependent upon prepotency, the value of which can be determined by the contrast of the improved and unimproved flocks. The prepotency of individual sheep can be judged only from a knowledge of their progeny. Since every sheep owner is not gifted with the knowledge of what to mate and what not to mate, this is a very great problem, but it is hoped these remarks may help to some extent. To mate extremes means disaster; if a medium between two extremes is desired it can only be achieved by working up gradually from one and down from the other. There is no short way in sheep breeding; the work requires patience and constant study.

LAMBING SEASON.

The number of lambs raised largely depends upon the care given by the breeder to the flock during the lambing period. The ewes require constant daily attention and new born lambs not strong enough to help themselves must be cared for. Undulating country is the best for lambing, as it enables the ewes and lambs to escape exposure to cold winds; the provision of shade and extra shelter are also of benefit. The increased number of lambs reared and the value of the ewes saved will repay the extra care during the lambing season.

LAMB MARKING.

The safest time for lamb marking is in dry, cool weather and when the animals are 4 to 6 weeks old. Cleanliness is essential and all knives and instruments must be sterilised and kept in a sterile condition by dipping in a good antiseptic whilst in use. All refuse must be cleaned from around yards and as far as possible the dust kept down. The animals must be firmly but carefully handled and should not be driven too fast either before or after the operation, otherwise heavy losses from bleeding may occur. The operations are performed in the order—earmarking, castration and tail docking. When the marking is completed the sheep should be held close at hand until all the lambs have been mothered, otherwise there is often a loss of motherless lambs.

WEANING THE LAMBS.

The lambs should be permitted to run with the mothers as long as possible. A paddock should be reserved for the weaners and the pasture should contain a variety of feed.

It is necessary that young sheep should continue to develop as they never completely recover if they once receive a severe setback. When separated from the mothers the lambs must not be left entirely alone; a few dry ewes run with them will help steady down the weaners.

COMBATING THE BLOW-FLY

The blow-fly pest, which annually involves breeders in heavy losses, has long since become a source of serious trouble to the sheep industry. Some years the mortality is much greater than others, due largely to more favourable weather conditions for the breeding of the flies. Breeders should watch the flock for affected sheep and apply suitable dressings immediately. Fly strikes, however, will be greatly prevented by the use of a good repellant after crutching.

CRUTCHING THE SHEEP.

One of the most efficient methods of combating the blow-fly is good crutching. The discolouration about the hindquarters of the animal is due to accumulation of dirt in the wool. This must be removed as it acts as an ideal breeding ground for the blow-fly. The work must be done as often as is necessary, but a systematic mass crutching should be aimed at instead of dealing with an odd sheep or two in the paddock, as is often the case.

The actual operation should be started by clearing the wool from behind the udder and between the hind legs. This section is done with the sheep sitting on its haunches, with its back leaning against the closed legs of the shearer. The animal is then laid slightly on one side and the wool removed from the back of the lower leg and just beneath the tail, then turned over and the opposite hind leg is treated likewise. It is advisable for a narrow strip of wool to be taken off from just above the tail. Great care must be taken when crutching pregnant ewes; there is no necessity for the shearer to lean on the sheep with the knee or press heavily on the flank with the fist. The rough handling of ewes results in premature births, malformed and dead lambs.

TICK AND LICE.

This is a matter of vital importance to the sheep industry. The farmer must be constantly on the alert to see that the flock is free from infestation. These blood-sucking parasites do much damage to the sheep and their wool. It is essential, therefore, to dip the flock. The ideal time to dip is from four to six weeks after shearing. Most of the standard commercial dips are suitable, and it must be borne in mind that for satisfactory results the instructions supplied by the makers must be strictly adhered to. Unless the sheep farmer makes a determined effort to eradicate these pests they will sooner or later reduce his sheep and wool to a very unprofitable state.

FOOT ROT.

The highly contagious character of foot rot is a proven fact and therefore any good system of treating an outbreak in a flock must include immediate isolation of the affected sheep. If this system is adopted early there will be every chance of

controlling the disease and curing the animals already affected. If the disease gets out of control, isolation is useless and foot-bath treatment will have to be replaced by hand treatment.

MAINTENANCE.

Every effort should be made in some way each year to improve production, otherwise flock deterioration will set in, and if neglected will increase every year. Farmers cannot expect to take everything from the land without returning a portion of the elements taken out in some form or other, and must therefore pay attention to the husbandry of his pastures. In addition to a utility shed for shearing each farm should have good yards with a drafting race. This will save considerable time and money, repaying the initial cost of the yards in a very few years.

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